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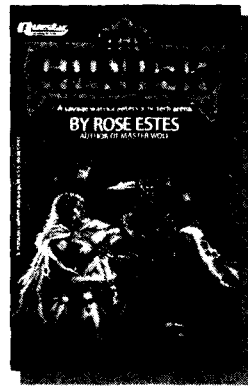

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When you see me around, ask me what you would get if you crossed SHOGUN and WAR AND REMEMBRANCE, and set it in the far future?

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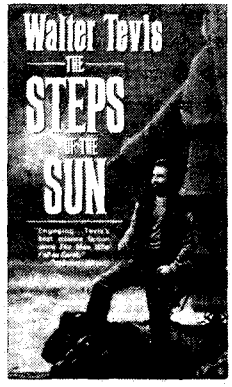

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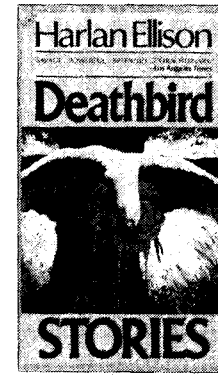

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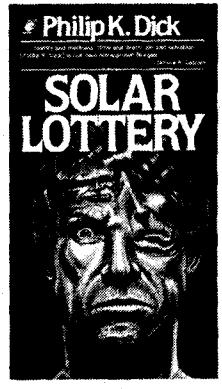

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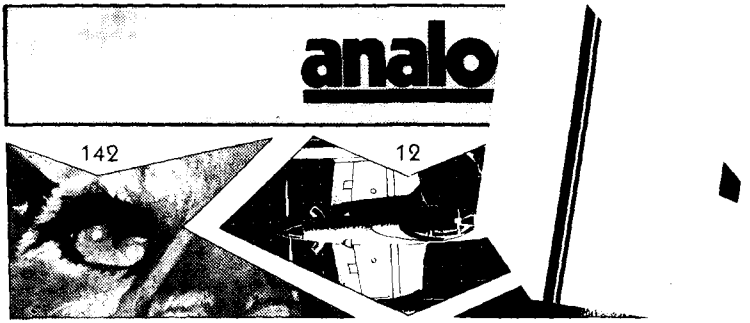

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Editorial

THE OLDTIMER EFFECT

Stanley Schmidt

There is a type of letter that I (and apparently every other editor) receive with some regularity, the gist of which is that science fiction (or some other field) has gone to the dogs and lost the magic that it had in the Good Old Days. Why, the writers of these letters ask, do the newer authors virtually never produce anything that can hold a candle to what the older ones did?

By a curious coincidence, a large majority of these letters come from people who have been reading the field in question for many decades. Not always; around the time I started thinking about writing this, I had recently collected several such letters from readers in their seventies or eighties—and one who had not yet hit thirty. OK, there's no intrinsic reason why a person of *any* age should like everything new (*I* certainly don't!), or even prefer art or literature produced in his or her own period to that of one or more earlier times. But when large numbers of people, mostly of relatively advanced age, express essentially the same complaint—that Things Ain't What They Used to Be—in regard to a variety of fields, and when this has happened in every period of recorded history. . . .

It gets awfully tempting to suspect the influence of some systematic phenomenon, something that tends to happen to human beings who live a long time and experience a lot—something that happens *as a result* of living a long time and experiencing a lot. I propose the name "The Oldtimer Effect," and define it as the tendency for people to find it harder and harder to appreciate new things as they themselves grow older. The evidence I've seen suggests that it is real, common, and has a significance that goes far beyond science fiction,

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painting, music, or any other specific field of endeavor. For example, at a time when some scientists are talking seriously about the possibility of greatly extending human life spans, it might be prudent to ask: how many people would really *want* immortality, or near-immortality?

"The Oldtimer Effect," I think, involves at least three closely related phenomena. A given individual may experience any one of them, or any two, or all three in combination.

1. *People tend to specifically remember only the* best *of the old stuff, and to mistakenly think of it as typical of the entire period.* This is almost tautological; "good," in regard to art or literature, might well be *defined* as "tending to stick in the memory." It's hardly surprising that the "not-so-good" doesn't. A selective memory has definite advantages for a being who collects decades of experience and has no need for ready access to most of it. But that doesn't change the fact that the not-so-good (or not-so-memorable) was there — frequently in larger quantities than what *did* stick in memory. In the Good Old Days, I'm sometimes told, science fiction was full of classics like _____, where the writer fills in the blank with a number of personal favorites. Furthermore, he or she may sometimes add, there weren't all those typos that these uppity young copy editors and typesetters and proofreaders let slip by.

It never seems to occur to most of these writers that the examples of How Good Things Used To Be are the *most striking* examples they've gleaned from among many others that they don't remember at all. I can't go along with the illusion because I have a complete set of back issues in my office, and have spent quite a bit of time exploring them *recently* in the course of compiling anthologies. I've *seen,* recently, the large amount of relatively forgettable material in which the gems are embedded (and I've also seen a good many typos, even Back Then). I've also seen it happen in other fields, such as the list of recent compositions being promoted by a major publisher of orchestral music on the back of a part printed some 30 years ago. I'd be very surprised and impressed if you recognized more than four of the 104 pieces or two of the 30 composers listed.

Occasionally the writer of a Good Old Days letter is perceptive enough to recognize that his memory of an old story may have been enhanced by the selectivity of memory or the fact that his tastes just weren't very discriminating when he first read it. Such a writer may strengthen his argument by adding that he has reread the old favorite and found that it was not only memorable, but held up well on rereading. But how much, and exactly what, does rereadability prove? It may reflect little more than the comfortable quality of familiar things with pleasant associations.

2. *The more things you've experienced, the harder it is to find new ones which are different enough from any of them to strike you as fresh and new.* Remember when knock-knock jokes were funny? To a child who's never heard one before, they really are. After

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the pattern has become familiar, and after you've learned to appreciate some others, it gets awfully hard to find a knock-knock joke that does much for you, because the elements of surprise and newness are gone. The same thing can happen with *any* kind of experience. You may continue to find jokes or symphonies or sports or people with characteristics that are new to you, but the more jokes or symphonies or sports or people you've known, the more new ones are likely to remind you of old ones. If your enjoyment of life depends on how different your new experiences are from your old ones, you are in ever-growing danger of finding more and more things boring.

3. On the other hand, *many people, as they age, don't really* want *much novelty*. The older they get, the more they fear the new and unfamiliar, and crave the old and comfortable. Instead of something fresh and new (even if they *say* they want that), they may really want more of what they liked from their

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own past—which would not satisfy many younger people who really are looking for something new and different. Thus it is that virtually every new form of art, literature, or music in history has been resisted by older generations (and frequently touted by younger ones to an extent completely out of proportion to posterity's eventual judgment of it).

Again, I emphasize that I'm not denying that a decline in the quality of anything, measured by whatever criteria you choose to use, can occur. Certainly it can, and both producers and consumers need to be on guard against it. Nor am I saying that anybody is under any obligation to welcome all new trends, or to favor the cultural works of any period over those of any other. After all, if the function of such a work is to do something positive for the viewer or reader or listener, whether it does so is the only significant test of its value. The result of that test can and will be radically different for different viewers or readers or listeners, without meaning that anybody is "wrong."

What I *am* saying is that those who would analyze progress or decay in such subjective matters cannot leave themselves out of the analysis. They need to be aware that their memories tend to retain only what is "best" by their particular standards, and forget that the rest existed. That tends to make the present look "bad," whether it is or not, simply because they have not yet had time to forget the less memorable majority of recent work. They need to be aware that the more things they've seen, the more things will look familiar—which tends to make even new ideas stand out less than they used to because there are more "old" ones around them. And they need to be aware that they themselves may become less receptive to new ideas, and come increasingly to yearn for the comfort of familiar ideas, patterns, and styles.

Since it is possible to do all these things *without* being aware of them, the same person may experience both of the last two manifestations of the Oldtimer Effect, even though they seem to contradict each other. That is, he may *think* he wants something fresh and new and be bored by his failure to find enough of it; yet when he does find it, he may find it disquieting and distasteful. That may make him wish for more like the Good Old Stuff; yet when he finds new work like that, he may complain that it is merely an unoriginal and unsatisfying imitation of things he has already read and remembers fondly.

None of this is intended as a personal attack on anybody who has experienced any of these tendencies. They are not "bad" or malicious; they are simply something that happens to people—and a rather sad thing at that, as anything that diminishes the enjoyment of life, whether internal or external, is sad. And probably none of us is completely immune.

Naturally there are exceptions. Some people are better than others at retaining a fresh outlook and finding new sources of satisfaction quite late in life. Some manage to do it throughout quite long

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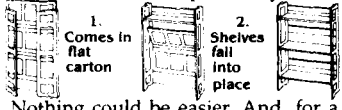

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lives. The composer Giuseppe Verdi did some of his most inventive and highly regarded work between the ages of 70 and 85. "Grandma Gatewood," a legendary figure among Appalachian Trail hikers, walked the whole 2,000-mile trail (again!) in her eighties. I have known several people personally who managed to keep exploring the Universe, and reveling in what they found in it, well into their seventies, eighties, or even nineties. I hope to be one of them, eventually.

But I have also seen the Oldtimer Effect in so many people that I must consider it almost an occupational hazard of being human. Sometimes it begins to take hold quite early. I have heard parents in their twenties say things like, "Having a child restored my joy in life," and I wondered privately why they had even begun to lose it that early. And while the prospect of very long life still sounds highly desirable to me, I must wonder how many people will really be able to enjoy how much of it. ■

SPECIAL NOTICE TO READERS

Beginning in 1990, we will be adding double issues to *Analog*'s schedule. Presently, the magazine is available every four weeks, or thirteen times a year.

The next anniversary issue will be virtually twice the size of a standard one, with even more of our stimulating stories and fact articles. A second special issue will be published six issues later.

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To understand anything, you have to collect data about it—and the best way to do that may be to go where it is!

Tom Ligon

FUNNEL HAWK

Vincent Di Fate

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A feeling of triumph swelled in me as I watched the twisting grey monster drop out of the swirling clouds. In three years of hunting, I'd never gotten this close to one. I brought the van to a skidding halt on the shoulder as my quarry squirmed like a dragon from a Chinese New Year celebration while it dipped its nose toward the ground looking for its dinner. It bit into the earth barely two kilometers away and started sucking energy from around it.

I keyed up the radio. "Van 1 to base, I've got one on the ground. Do you have a fix on me?"

"Roger, Susan. We have you. Keep us informed."

I snapped a few pictures, then hurriedly began setting up my instruments. I kept one eye on the beast, which was tracking with deliberation across a field to my west, heading roughly northeast. It wasn't an especially large example of the genus, but it was impressive enough at this range, compact and sinewy. Its roar was everything I'd heard it would be, penetrating into my chest and sending shivers through my marrow like a megawatt of bass guitar at a rock concert.

I just about had the instruments in position when the monster crossed the road on which I was parked about a kilometer and a half away. Except, it didn't cross the road. It locked onto the warm asphalt like a train on a railroad track and headed straight for me. I watched for perhaps half a minute, fascinated, but calmly expecting it to resume its previous track. Then a sudden conviction hit me. *This thing was out to get me!*

I slammed the instruments back into the van and swung into the driver's seat. My heart was pumping near redline as I grabbed the mike. "Van 1 heading east in evasive action."

A glance in the rearview mirror showed the menacing creature still after me, still tracking straight down the middle of the only road available. I slammed the shifter into drive and put the pedal to the metal, tossing gravel in the general direction of my pursuer. I hadn't gone a kilometer when I found my path blocked by a downed tree. Mind you, there wasn't another tree in sight. Naturally the only tree on the road would pick that day to fall down across it. I pulled over onto the shoulder and edged around the tangle of branches. My right wheels dipped into the ditch, and forward progress stopped.

"Don't panic," I told myself as I stole another peek in the mirror. "You've got time. Don't spin the wheels. Rock it out."

I shifted into reverse and eased on the gas. The van backed up an inch, then spun the stuck rear wheel. I put it into forward and nudged the throttle again. The van moved forward an inch, then spun the wheel. I repeated the process twice. The range of movement decreased, if anything.

The roar from my pursuer was getting louder by the second. I looked in the mirror. The creature was bearing down on me, not even half a kilometer away. "OK then, *panic!*" I mashed the pedal to the floor and dug the rear wheel nice and deep into the mud.

I wasn't stuck for long. The elephantine snout stretching down from the sky

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found my van and wrenched it free like a monkey picking a banana. First, it merely knocked the van on its side and skidded it through the field a short distance, then it reversed direction, the way a cat plays with a crippled mouse. Next the monster grabbed the vehicle in its jaws, picked it up about five meters, and shook it. When it was quite certain its victim breathed no more, it dropped the van and continued down the road.

When the freight-train roar finally died down, I cautiously stuck my head up out of the passenger-side window. I had to climb over a lot of stuff to do it, but since the driver-side window was stuffed into a ditch . . .

I sighed with relief. The monster that had put me there seemed to be dying, a victim of the very forces that had created it, if our theories were any good. As such things go, it was losing power rapidly as it looped drunkenly through a cornfield about a kilometer to the east. I eased my camera up, wincing as I discovered the beginnings of a huge bruise, and took pictures as it gasped, then died, dropping debris from where it had towered ten thousand feet or more above the Kansas plains.

I looked back down the road, along the path I had taken trying to avoid it. Utility poles were mowed down flat like wheat after a hailstorm, their power cables lying on the ground, bright blue arcs dancing over the wet pavement. A school bus shelter lay nearby, broken and flattened. Across the fields was a contorted brown path of naked earth a hundred meters or more across. But the sky to the west was bright and blue, except for a magnificent band of orange on the horizon, contrasting the rumble of thunder behind me and the devastation around me. It was a glorious end to a very . . . eventful . . . day.

I ducked back into the van to survey the damage I was more directly answerable for. A quick look told me the toll to the equipment was surprisingly light, considering the van had taken a dive of over ten meters through thin air. The van itself would probably be declared a total loss. My biggest disappointment at the moment was that the radio was out. I settled down to wait for my no-doubt panic-stricken teammates to find me.

I had plenty of time to consider that this was a hell of a way to study tornados.

The next day I limped into the project director's office to make a modest proposal. Dr. Lyles looked up at me from a pile of repair estimates on his desk, studiously trying to look disgusted, but probably secretly pleased he wasn't composing a eulogy.

"You said you had something important to discuss," he grumped.

I grabbed one of the battered oak chairs near the wall, plopped it in front of his desk, and sat down. I got back up, exchanged it for a chair that wasn't broken, and sat down again.

"We're doing this all wrong," I said.

He stared back at me over his reading glasses, poker faced. "Well, one of us is, anyway. The idea is for *you* to chase *tornados*, not the other way around."

I shrugged. "If we knew which way they were going to move, we wouldn't have to study them. Anyway, I'm not the first tornado hunter to become the hunted. I would kind of like to be the

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last. That fifteen meter dive isn't something I'd like to repeat anytime soon."

He hefted the repair estimates. "Keep this up, and you may be. The budget is tight as hell. The National Severe Storms Laboratory itself is feeling the crunch, so a little peripheral activity like this one is in real jeopardy."

I nodded. Technically, we weren't even part of NSSL, just a university meteorology department willing to put warm bodies out in the field at minimal cost. "Exactly. Which means we can't keep wasting money like we have been. We've been chasing funnels like this since '72, and what do we have to show for it? Almost nothing! Thunderstorms don't have to follow roads, but we *do*. And we aren't fast enough. We're lucky if we're within two hundred miles of a tornado when we get a radar report of a hook reflection, and even pushing the high end of what passes for the national speed limit out here, there is usually no way in hell to get to a storm in time."

He leaned back in his ancient chair, which creaked at every joint as if it had arthritis, and put a finger on his lower lip. "And you're proposing . . . what?"

"We use a plane." I tossed a packet of sketches on the desk.

"This meeting is over."

"Hear me out."

"It's crazy. You're complaining about a little ten or fifteen meter fall, and you intend to take a plane up in that kind of weather?"

"Closer to twenty meters," I corrected him. "Crazy is driving around on the ground trying to study atmospheric phenomena occurring thousands of meters up. Besides, in a plane, I'd have more directions to run away. And it's really just a logical extension of the old Government Thunderstorm Project Byers and his bunch put together back in '46. They used P-61 Black Widows to take measurements inside cells. In fact, they even used *sailplanes*."

He raised an eyebrow in suspicion, then apparently decided maybe I had some technical grasp of my proposal. "How do you propose to pay for it?" He gestured around to the hand-me-down furniture.

I smiled. "Ambitious projects have been known to receive substantial grants, especially if they promise to be more productive than previous approaches. I'd like permission to see what I can scare up."

He picked up the sketches and thumbed through them quietly for about a minute. "I see you've given this some thought. Have you given any thought to who would fly it?"

"I'd be willing," I offered.

"I thought as much. You got your license, what, a month ago?" he asked. "You fly what, a Piper Cub?"

"A Cessna 152. I've had my Private for almost six months, and, including instruction, I've been flying for a year and a half."

He looked dubiously at the sleek design I had dreamed up. "And you think you're ready to fly this . . . rocket . . . into tornados?"

"I could be, by the time it's ready to fly. Development will take at least a couple of years. They teach fighter pilots in less than that. Besides, I don't really intend to fly *into* tornados. Just close enough to get a good look."

He looked at the sketches again. "Hell, maybe you're right." He looked

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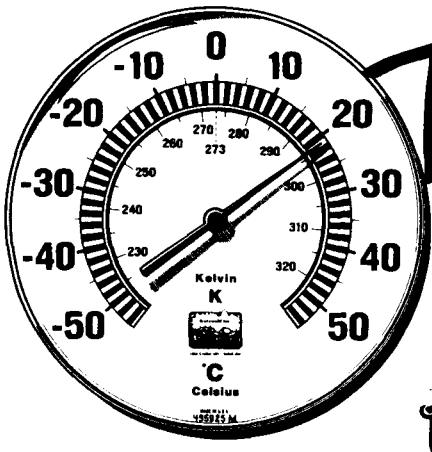

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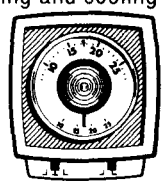

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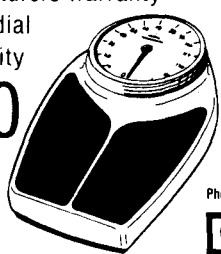

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at a photograph of my wrecked van and the cockeyed shots I'd gotten of a grey blur in the sky. "Hell, I *know* you're right. We've always known the limitations of ground-based methods. It's still insane." He looked around the office again at the evidence of academic poverty. "All right, you can poke around and see if there's a possibility of some funding. For a feasibility study, that is."

I smiled and thanked him, then got up to leave.

"Susan," he called to me as I reached for the doorknob, "you've got guts, I'll grant you that."

My flight instructor at the campus airfield was also a full professor of Aerospace Engineering. I dropped by Dr. Hodge's office with the sketches later that day.

"Slick," he said. "What's it for?"

"Chasing tornados. Not actually flying in them, just chasing them," I added to preempt the inevitable. "Do you think it's possible to build a plane that will do it?"

"Maybe. Build it out of graphite composites, give it gutsy enough powerplants. Crazy as hell, though. I suppose you want to fly it?"

I nodded. "Unless you know someone else crazy enough to want to. I figure I know as much as any pilot about what makes a tornado tick. I'll admit, we don't really know all that much, but that's exactly the point. Tornados are dangerous. They kill about a hundred people a year and destroy thousands of buildings. The risk is worth it if we could better predict when tornados would form and what they would do."

"You've never flown through a thunderstorm," he said, his face growing suddenly ashen. "I have. I got caught in one once. Got boxed in by some really nasty ones and had no choice but to bull right through 'em."

I raised my eyebrows. "In your Baron?" I really didn't think his twin-engined light plane was up to it.

He nodded. "Yup! Tops at forty-five thousand feet, and full of hail. I've never been so scared in all my life. Yeah, we can build a plane that will take the stresses, but staying in control is another matter. And you're talking about superstorms here. A storm like that will take any plane made and toss it around like a paper cup. We can't build a pilot that can handle it."

I smiled. "It may not be as bad as you think. Tornados always form on the trailing edge of cells. We think they're caused by a complex interaction of streams of air spilling down from the back of the cell, air getting sucked into the side, and warm air rising. This tends to create a formation called a mesocyclone, which in turn generates a twister maybe half of the time. We know a lot of features associated with these phenomena, but we don't understand why they sometimes form and sometimes don't. What I *am* sure of is that what we need to know can only be learned in the air. I would be flying behind the storm, feeling out these winds, measuring air pressure and temperature, and taking pictures. I'd be in high, turbulent winds, but I'd be in fairly clear sky, with plenty of altitude to recover from the unexpected."

"And laden with instruments so you could tell what was going on," he

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added, nodding. "Yes, I can see it. And for about the same reason, an RPV could never do it. A knowledgeable human at the controls is the only way to deal with such an unpredictable environment."

I nodded. "That's the way I see it. Maybe, after we learn more, we could use remotely piloted vehicles for routine weather monitoring, but not at first."

He pointed to some features I'd drawn on my top sketch. "What are these?"

"Rockets," I replied. "They're to inject chaff into areas that look too risky to go into. I figure they'll have to have very light casings or other measures to keep them from doing any damage when they hit ground. I'll also carry fighter plane chaff packets to dump out the back."

He nodded. "So your approach is to give local radar installations something to get a reading from?" He started adding details to my three-view sketch. "As I understand it, you're primarily interested in studying the winds that feed into the mesocyclone. You want to find out what forms it?"

"Yes."

"Then, might I make a few suggestions? We borrow a few ideas from the air shows. Smoke, for example. It would give you a visual aid while you're feeling around up there. You could also drop smoke bombs or streamers to watch changes in wind velocity on the way down. Parachute jumpers do that."

I was starting to feel pumped, then he suddenly balled up my drawing and threw it into a wastebasket. "What'd you do that for?" I protested.

He pulled out a fresh sheet of paper, and started making a quick but amazingly finished-looking sketch the way only a master designer can. "The engines should produce thrust on the centerline," he explained. "Makes it as easy to fly as a single, and much better in unpredictable conditions. My old boss, Kelly Johnson, considered an almost identical design for the old P-38."

I watched as the design took form. Its mother was a Cessna Skymaster and its father was a Lockheed Lightning. It was beautiful, with trim, sleek lines, a bubble canopy like a fighter plane, a pointy nose bearing a broad-bladed prop, and twin booms supporting the tail. A second engine was mounted behind the cockpit in a pusher configuration.

"I thought about making it a jet, but turboprops are better suited," he said, obviously becoming immersed in the project. "Better at low speed, less likely to flame out, and lets you fly from small runways. Twin Allison turboprops should give you the equivalent of about a thousand horsepower, a little less than Second World War fighters had. With modern materials and airfoils, it should outperform the old warbirds. Counter-rotating props so you won't have a torque reaction, too."

I pointed to the twin booms. "Do you have anything in mind to go into these?"

"Fuel, perhaps. Why?"

"The spacing is about right to put millimeter wavelength radar in each one, giving me interferometry capability."

"You've got it. Anything else?"

"I hear graphite absorbs radar. Can we do something about that? I'd like to send back a nice, strong reflection."

"Sure. We could metallize it some-

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how. With a little attention, we can also optimize the angles to make good corner reflectors. I figure this will be a two-seater. You agree?"

"Yeah, there may be someone else as crazy as me, somewhere."

We went on like that for hours. We finally noticed it was way past midnight, and realized that if we went much further, we might actually fool ourselves into believing we could get this marvelous machine funded. We decided to call it quits for the night.

"Susan," he said as I reached for my coat, "I know you're excited, but try to take a realistic view of this. I've seen a lot of new pilots who had more confidence than they ought to. I've seen plenty of accidents caused by the same thing. This plane we've dreamed up . . . this is a hyper beast. It could be fairly safe, for what it is, but it will be fast, powerful, agile, and it could get you into trouble in an instant."

I nodded.

"And you're intending to take it into harm's way. What I mean to say is that even a really good pilot won't be good enough to fly this plane in an environment that severe. This will take a *great* pilot."

"And you wonder if I have, dare I say it, the 'Right Stuff'?"

"That's putting it more bluntly than I had in mind," he replied. "And its not just because you're a woman. I don't think *I* could handle this beast under those conditions, at least not with a margin of safety I'd feel comfortable with."

"You're saying?"

"I'm just saying, don't get so stoked up on this that it clouds your judgment if and when the time ever comes to fly this thing. In all likelihood, we'll have to get an experienced test pilot to drive this bird."

"Assuming we get a chance to build it," I added.

"A very, very big assumption."

I went home that night too agitated to sleep. I retired to my study and plopped down in front of the computer. On a whim, I turned it on and started to play with some of the flight simulations I'd bought before I worked up enough commitment to tackle the real thing.

I called up the simulation of the SR-71, the ultra-fast spyplane with the ultra-bitchy personality. I eased it up to the fringes of space, as high as it would go without flaming out. I held it level at eighty-five thousand feet until it wound up to a little over Mach 3, and pulled back on the stick to send it up past where wings, ailerons, and stabilizers have any meaning. My ballistic arc peaked at about a hundred and eighty thousand feet, a personal best. The plane plummeted sideways back down to where there was some air to work with. A little subtle coaxing brought it back under control. I landed it gently by holding the nose improbably high in the air, remembering all the times I had sheared the wings off on reentry, or evoked the wisecracks of General Yeager himself by digging a trench in the runway.

I evoked the master test pilot's game of tag, and chased the crusty old devil around the sky in everything from a Sopwith Camel to a fighter jet. I realized it had been quite a while since he had been able to shake me.

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I called up the air war in the Pacific, and proceeded to pummel the Japanese into submission. For the dozenth time in my illustrious career as a fighter jock, I nailed all nine Val dive-bombers before they could reach the Yorktown. I racked up the usual assortment of promotions, medals, and gold stars, then checked the "Best Missions Ever Flown" board. I was in second place, behind a Japanese gentleman who'd gotten eight planes and two ships in one mission, flying a plane carrying one warhead. He can *have* first place.

I called up the F-16 Falcon. Sarge would only allow me AIM-9J Sidewinders, no good for head-to-head conflict. I took six, plus the usual 5,000 rounds of 20 mm (enough for five seconds of firing). A few minutes later, the countryside was littered with the smoking ruins of ten MiG 21 jets, five the victims of heat-seeking missile suppositories, the other five taken out by cannon fire up their sixes. That's why my call sign is Major Catastrophe.

I felt smug and self-satisfied, sure I was up to my eyeballs in the Right Stuff. But then, I reminded myself, these were only simulations, and necessarily lacking in some of the finer details of real-life flying. I called up my most realistic simulation, and set up the most challenging conditions I could.

I took the Cessna 182 RG Turbo up into the nastiest crosswinds and thunderstorms the computer could dream up. Time after time I ducked into storm cells, got bounced around a little, and was spit out the side thousands of feet higher than I went in. The little computerized plane took it without a whimper, and it seemed impossible to get hurt. Of course, while I was actually in the storm, I had no idea which end was up. I was also invariably caught in an updraft. And the real-life situation I was planning to fly into featured down drafts every bit as violent, but pointed at the cold hard ground.

And attempting to land the Cessna in a 20-knot slightly gusty crosswind, I cracked it up.

I mentioned the proposal to a few other colleagues in the course of the next week. A definite pattern began to emerge. The ones who really knew what was going on, my frustrated comrades in the aging fleet of vans, thought the idea was insane and practical at the same time. Virtually everyone else thought the idea was merely insane. A big thunderstorm, they pointed out, can have more energy than an atomic blast.

The prospects for funding looked bleak, too. No government grants existed to cover quite this type of research. Program money available through the normal channels was preordained to go to specific areas, none of which seemed to carry quite the spirit of danger and adventure. A few years earlier, it would have been fairly simple to approach our congressman about a special appropriation, but a number of institutions had abused that process to the extent that it was no longer a viable option.

And it became obvious that funding was going to be critical. Even a modestly high-performance light plane such as a Beechcraft Bonanza would have set the project back about as much as ten vans, and a light plane was out of the question. We were talking about a custom, one-off, high-tech design, with all

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the development and testing of a modern fighter. The way the aircraft industry went about it, that would take hundreds of millions of dollars and five to ten years.

Dr. Hodge had figured it a little differently. He was a product of the old school of aircraft design, the school that built the magnificent warbirds of the Second World War. He'd actually *worked* for the legendary Lockheed Skunk Works, which had built some of the hottest planes in history. Their approach was to start with a sound intuitive design, build the sonofabitch right, test fly it, fix the problems, *then* make the drawings. It was a productive approach, but it had been known to require considerable consolation of the widows of test pilots.

Our university had a few ways of simplifying the process, however, not the least of which was Dr. Gerald Hodge. The second was a fairly decent supercomputing center. The third was a synergy between the two. While Jerry was himself no whiz with computers, he appreciated them fully, and was an expert at inducing young computerphiles to teach our Crays the finer points of aeronautics. Jerry's approach to aircraft design and testing was to get past the mangled test pilot phase digitally, using graduate student slave labor and computer time bonus bogus bucks.

By Jerry's way of figuring, if we kept the design straightforward, the plane could be designed in six months and tested in another three. Furthermore, it could be done as an educational exercise with no expenditure from any research budget. In essence, the designers would pay their tuition for the privilege of designing the plane. The approach also gave us time to find the money to actually *build* the thing. Having a workable design in hand would help.

Actual construction would take another year or so. The Aerospace Engineering and Materials Science departments had a small joint laboratory for graphite fiber fabrication. While they had never tackled something so ambitious as an entire plane, it was by no means out of the question. With half a dozen man-years of student slave labor, Jerry figured the cost could be kept down to around three million, including engines and avionics, not including the special meteorology gear.

In fact, Jerry was totally optimistic about the technical feasibility of the project. His big reservation was the regulatory process. Not only would we have to go through the normal certification process with the FAA, we would have to convince them to let it fly under conditions that flew in the face of the rules they lived and breathed.

Nevertheless, we started making inquiries with the authorities, hoping for the best.

The best was not forthcoming. I was called on the carpet by no less than the university president. And, I might add, it was an impressive carpet, big and expensive, covered with tastefully elegant furniture.

(Before I go any further, you may notice that I sometimes neglect to use names. My momma always told me, "If you can't say something nice about someone, why lay yourself open for a libel suit?")

I stood before his expansive, shiny

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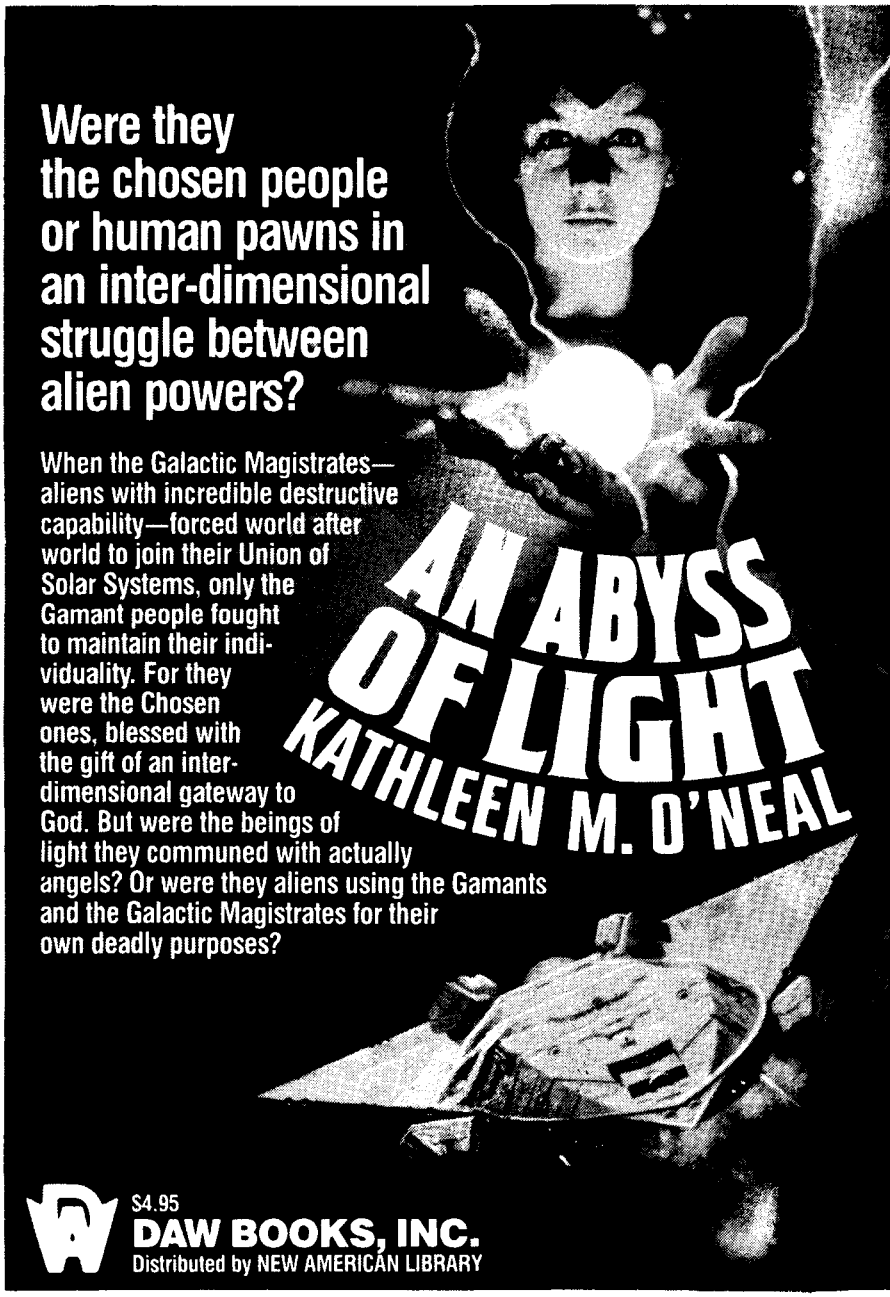
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slab of hand-oiled mahogany wondering how anyone who did useful work could have so little on their desk. With less than a third the space I would be able to actually lay out *two* US Geological Survey 7.5 minute maps side by side. I waited for close to a half an hour while he took one phone call after another, ignoring me, no doubt to let me know how utterly unimportant I was in the scheme of things.

Finally he deigned to grant me the audience he had ordained. "Miss Denton, it has come to our attention that you have been pursuing a highly dangerous and unauthorized line of research."

He paused, waiting for me to fill in the silence with some damning self-incrimination. I waited for him to clarify. He waited, too. I broke down. "I have been, with Dr. Lyles's full knowledge and permission, looking into the feasibility and fundability of a new approach to ongoing research."

He tapped his pencil on his desk as I wondered just what use he had for a pencil. "Miss Denton, how can you seriously consider the feasibility of flying a plane into the most violent weather conditions on the planet? It would be suicide!"

"Sir, as I keep telling everyone involved, we have no intention of flying *into* tornados. Our interest is in investigating the patterns of air movement which create them. There simply is no way of doing that from the ground, and our computer simulations have gone as far as they can without actual data."

The pencil stopped tapping momentarily. "So you're telling me that you intend to fly a plane into conditions you don't understand. I see." He initiated another deadly pause. I fell for it.

"If we already knew the answers, we wouldn't have to do the test. It's the only way I can think of to get the answers we need."

"Well, you'd better *re-think* it," he said, rearing back in his regal, leather-upholstered throne. "Miss Denton, I'll be quite blunt with you. I will not have the prestige of this institution threatened by a hare-brained scheme like this."

I don't know if he intentionally pushed it, but one of my sure-fire buttons is the subject of institutional prestige. I blew up. "How in hell does this threaten the prestige of the university? How could a sure, quick, successful program for unlocking the secrets of one of the most dangerous, capricious, natural phenomena, one that kills over a hundred Americans every year, possibly hurt the prestige of this institution? How could —"

"That's enough, Miss Denton!"

"—how could spending endless years driving aimlessly around the midwest, spending taypayer money with almost no chance of learning anything useful while risking the lives of the researchers (I pointed to myself), *possibly* enhance the prestige of this university?"

"Miss Denton, do I presume that, when your doctoral studies are complete, you may wish to pursue tenure at this or another university? Then please control yourself."

This time *I* initiated the deadly pause. This time *he* gave in.

"Miss Denton, I fully appreciate your enthusiasm for your work, and indeed I admire your considerable courage at being willing to fly such a mission.

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However, you must consider my . . . or rather I should say the university's . . . position. We must consider the public perception in the all too likely event of . . . a tragedy."

"Sir, I respectfully submit that the history of aviation is one of public adoration of courageous fliers, including those who have lost their lives." I chose my own personal favorite as an example. "Amelia Earhart is a case in point. And I might also point out that for years this country has routinely sent hurricane hunters into bigger storms than I am interested in."

"I am sure you are correct, Miss Denton. However, as I am sure you are aware, both examples you cite have something in common. Hurricane hunters do their work over open water, where a crash would be highly unlikely to cause any damage. I suspect they also stay well clear of conditions likely to spawn twisters. And your Amelia Earhart disappeared at sea."

"So?"

"So I will not allow you to pursue any course which might lead to me opening the morning paper and finding a front-page story with two photographs, one showing the tail of a plane emblazoned with the university logo sticking out of the side of an elementary school, and the other with your pretty face captioned as the idiot who killed thirty-two innocent six-year-olds. Furthermore, I am sure we could never adequately insure such a project."

"In other words, you're saying that no matter whether or not the potential benefits to society outweigh the personal risk to myself, and no matter that a successful program would be a great feather in the university's cap, you're scared silly that a one-in-a-thousand accident will hurt your precious prestige?"

"One in a thousand?" he asked incredulously. "That changes things considerably. I was figuring one in ten thousand! That settles it. Absolutely no!"

"And I am to drop the project entirely?" I was hoping to trap him into violating a sacred principle of the university.

"Oh, I won't go so far as to say you cannot pursue the concept. I won't be accused of interfering with academic interests. Miss Denton, you are free to pursue all the concepts you wish. You are free to pursue all the money to investigate all the concepts you wish. Just understand that you will never, under any circumstances, get this project off the ground. Literally."

I left his office feeling just about as low as I could get. When I got back to my office, I found a letter from the Federal Aviation Administration. It rejected, out-of-hand, the entire concept for the project. I spent the rest of the day down at the airport watching people who still had some enthusiasm for life do touch and go landings.

For the remainder of the summer I let the project drop, despite encouragement from both Dr. Lyles and Jerry Hodge. There really didn't seem to be any point. My lack of enthusiasm showed in my work, too. I became decidedly less aggressive at chasing funnels. My coworkers blamed it on my close call, but I knew better. You can't be happy

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swinging a sickle once you've figured out how to build a harvesting machine.

I plodded on through the rest of the tornado season, usually with a copy of one journal or another stashed in my briefcase and opened to the classifieds. I revised my resumé and compiled a list of prospective employers, but never worked up enough gumption to actually send out any letters. I couldn't imagine any of my prospects having the guts to go ahead with the project. I was actually seriously considering becoming a weatherperson at some podunk television station somewhere.

I was also still troubled by doubts about my own ability. I'd lost the cockiness I'd had about my flying talents. I stopped flying entirely, even on my computer.

About halfway through the fall semester, I passed an office late in the evening. Something inside caught my eye. I turned back to investigate. Seated at a high resolution terminal was an undergraduate. On the screen was a flight simulation, one of the best I'd ever seen. He was controlling it through a joystick plugged into a laptop PC attached through a tangle of cables to the terminal.

He seemed nervous when he saw me, but waited to see what I would do. I came up for a closer look. "I've never seen that one before. Mind if I watch?"

"Uh, wrote it myself," he replied, squirming a little in the chair. "The commercial stuff either isn't realistic enough or isn't fast enough."

I watched the beautifully detailed graphics flow across the screen. "This is incredible. How did you manage it?"

The squirms became intense. "Uh, the computer I'm using is pretty quick."

I glanced at the laptop unit, then at the terminal, which was still linked to a jack on the wall via a fiber-optic cable. I pointed to the laptop unit. "You're kidding. That isn't even an AT compatible."

I thought he'd curl up like an anchovy. Instead he straightened up and admitted it flat out. "The laptop is just used for the keyboard and joystick controller. I'm using a supercomputer."

I'd guessed as much. "How did you manage the access?"

He shrugged. "I know it's against the rules. I didn't steal the number, though. I use one of the old processors that isn't used this late at night. I have a valid account for an undergraduate research project I'm working on. I only use a few dollars worth of time a night, its capacity nobody needs."

I had him just where I wanted him. I pounced. "Mind if I try it?"

He smiled and slid over. "Sure!"

I noticed his joystick was plugged into a box with several extra knobs. "This thing uses the MicroSoft controls?"

"Yes, ma'am. Plus a few I've added. I have more views and a scan mode. This knob controls throttle, this one is pitch, the last one is mixture. The one on the front is rudder."

"What are we flying?"

"You're escorting B-17s in a P-51D Mustang over Germany in 1944. The bombers are behind you and to your left. There should be a group of Focke Wulf one-nineties showing up any time now."

Fifteen seconds later I spotted them at nine o'clock. I nailed the throttle and began climbing into attack position. The plane seemed a little sluggish.

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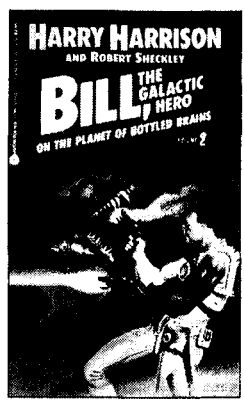

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"Press Control-C to jettison your external tank," he advised.

I nodded, recognizing the Falcon's similar command. The Mustang now handled as it should. Fifteen seconds later I was closing with the German planes and lining up the first. Suddenly he snapped over and started a dive under me. I pulled up, rolled over, and did a split S. I spotted him an instant later below me, pulling up and to the left. He was good, but not good enough. Three seconds later I was pumping fifties into his wings.

As soon as I polished him off, I turned back to pursue the other three planes. They fell in short order, despite their best efforts to evade or engage me. I must have been grinning like an idiot.

"Hey lady," my young friend exclaimed, "you're *good!*"

"Yeah, I know." And for the first time in months, I *did* know it. "So are you. How'd you like a chance to do this on the up and up?"

He looked at me dumbfounded. "My only dream in life is to get a job building real, honest to gawd simulators. Except, of course, to fly, too."

I nodded agreement on the last point. "I'm involved in a project to design a high-performance plane for researching severe weather. We already have the software to predict how it will handle, and we have software that models the behavior of the atmosphere. What we don't have is a decent simulator that can let a pilot actually fly it in simulated severe weather."

I had his attention.

"In fact," I continued, "I even think I know where I can find an old Link trainer chassis we could hook up to this contraption. Interested?"

He was interested. I went on. "Of course, you'd have to put in *hundreds* of hours testing and refining it. And we might be forced to require you to take flying lessons so you can make it more realistic."

At that, I figured I'd better lay off the hard sell. The poor kid looked like he might have a heart attack any second. I offered my hand. "What's the name, ace?"

"Ed Cunningham," he replied.

Meeting Ed pulled me out of my funk. I introduced him to Jerry, and they hit it off like a father and son. Come to think of it, they hit it off better than that. Jerry gave Ed an unlimited wealth of knowledge and insight on the subject of flying, and Ed gave Jerry his youth again.

I still realized the project could never see fruition. It no longer seemed to matter. What mattered was that I was once again able to put my heart into my work. The nice thing about being a simulator pilot is that you learn how to live the dream as if it were the real thing.

Our plans centered on supercell research for several reasons. Supercells, really tall and energetic thunderstorms with segregated updrafts and downdrafts, had always been at the heart of tornado research. These monster storms were far more likely to produce tornados than the milder, ordinary thunderstorms. Furthermore, the tornados they produced were more likely to be killers. Finally, if we were merely dreaming, we might as well dream big.

True to his prediction, by the spring

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Jerry had the plane off the drawing boards and into the simulator. Dr. Lyles had put a graduate student onto adapting the best available simulations of supercell winds into a form suitable for a flight simulation. Ed integrated the two into his code, and together we set about learning to fly it.

We left the combat simulation intact, for comparison purposes, you understand. By comparison, nothing else in the sky had a chance, including Messerschmitt 262 jets. Our plane could outturn anything, out-climb anything, and what it couldn't out-run, it could outlast. It could even survive a trans-sonic dive. It easily did over four hundred knots in level flight at 25,000 feet, which is 460 miles per hour for you non-flying types.

Word quickly spread around the Aerospace Engineering Department that a bunch of loony-toons were designing a plane to chase tornados. "Wizard of Oz" gags started to appear on the door to the simulator room. Before long, we gave in to it. Jerry peeled up a strip of floor tiles leading to the Link, replacing them with a yellow brick pattern. Ed wanted to dub the trainer "Toto," but NSSL had already taken it for an oil drum full of instruments they kept trying to pitch off the back of a pickup truck into the path of a tornado. After a few embarrassing flights, we settled on "The Wicked Witch of the Mid-West."

Flying the Witch in bad weather was an eye-opening experience. I had never expected it would be that difficult. By that time, I was a tolerably decent instrument pilot, but on instruments you avoid extreme maneuvers. Simulated clear sky aerobatics under good conditions had never bothered me, either. But our best model of the likely winds behind a supercell proved a humbling experience. Sometimes the only thing I could do was use the considerable power of the twin simulated Allisons to duck out of the airstreams. Otherwise, I was virtually helpless.

Inside of our supercell thunderstorm simulation was even worse. It combined violent and unpredictable winds with zero visibility, which proved to be my undoing. The instruments, including the gyroscopic "artificial horizon," were nearly useless, and I became totally disoriented in the wildly gyrating trainer. The simulator predicted a fatal outcome 80 percent of the time. Finally, we added one additional instrument, an electronic device that kept track of orientation by signals from a navigation satellite. With that one instrument, I was finally able to get some sort of fix on which way was up, and improved my survival rate dramatically, to about the same as a game of Russian roulette. I now fully understood what Jerry had told me about flying in thunderstorms. It was something to avoid.

We started to catch some flak from the supercomputer center about the amount of processor time we were using. People with actual funding were to have priority. Ed suggested he could make the software work on a small computer if he could do a little multiprocessing. I sweet-talked a major manufacturer into giving us an experimental model with a 486 multiprocessor and a graphics processor. Ed dug into the manuals, rewrote the most critical parts of the code in assembly language to fit the new hardware, and we ended up

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with a simulator that ran a little better than it had on a Cray.

My involvement with the project went on hold as summer drew near. The tornado belt worked its way up into our area with a vengeance, racking up one of the worst tolls in recent memory. I spent most of my time in the field, driving a van at a breakneck pace through the midwest, trying to stay in the path of the worst cells NSSL and the National Severe Storms Forecast Center could spot. As usual, the rewards were few, with the funnels usually too far away to reach in time.

We were beginning to see some results from the increased number of Doppler radar installations, however. These technical marvels could actually measure the velocity of windborne raindrops, allowing us to spot a mesocyclone forming. Nevertheless, we were still limited to measuring wind, pressure, and temperature at ground level, augmented by what little we could learn from videotapes of cloud motion. The key winds we were looking for were suspected to come in from clear air. My frustration with our methodology continued to grow with every futile chase, but my enthusiasm for the airborne project grew equally.

A really bad line of storms came in from the west in mid-July, spawning record numbers of tornados. We spent thirty-six hours continuously in the field, chasing the monster cells that looked most promising. We were usually rewarded only with black clouds and flashes of lightning on the horizon, though twice I caught distant glimpses of funnels snaking their way toward the ground. The storms finally outran us, and we turned our vans to meet at a small motel. I was ready for a hot shower and a warm bed.

Ten miles from the motel, I got a call from Dr. Lyles on the radio.

"Susan, we just got a call from the FAA. They want to meet you immediately. Think you can go directly to the airport?"

I groaned before keying up the mike. "Any idea what about?" I was afraid to even consider that it might be about the plane.

"Not really, but this guy wants to meet with you tomorrow morning. Says it's urgent."

"Yeah. Can't I stop for a shower first?"

"Not if you want to catch the last flight to Washington. Do you have a change of clothes? You'll have a couple of hours in a hotel before you meet him."

I looked at the overnight bag on the seat beside me. "I'm packed. Never got a chance to change. Yeah, I'm heading there now. I suppose you'd like me to charge the ticket on my own credit card."

"Would you? We'll reimburse you by payday."

Well, as luck would have it, the red-eye I was supposed to catch was delayed. I had to kill four hours in an airline terminal in those nasty plastic scoops they call seats. You can't sleep in them without sliding out on the floor. The plane finally arrived, I'd guess about ten minutes before I would have gone comatose. I got about two hours of sleep on the plane, interrupted three times by an overly helpful stewardess

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offering me tiny little pillows, advanced coffee substitute, or rubber food.

We arrived in Washington ten minutes after I was due to meet a Mr. Keitt, who was one of the honchos in the Doppler radar project. I staggered into his office looking like one of the street people sleeping on a grate in Lafayette park. He didn't seem to notice.

"Pleased to meet you, Mrs. . . . Miss? . . . Denton. Please have a seat. I wanted to discuss your proposal."

I perked up. "I was hoping you would. I've just spent the last couple of days chasing that line of big ones out west, and barely caught a glimpse of two funnels. I—"

"Miss Denton," he interrupted, "quite frankly, we're still opposed to the idea of chasing tornados with aircraft. We know the problems you face, but we also know our business. We are a long way from being convinced it can be done with an acceptable margin of safety."

"Then why am I here?"

"Can't you guess?"

I indicated that I hadn't a clue. He produced a *Washington Post*. The quarter page picture of the wrecked airliner was just under the banner headline: "SENATOR'S WIFE AMONG 121 KILLED IN AIR TRAGEDY."

"Crashed on approach to Denver-Stapleton while thunderstorms were in the area," he explained. "I guess you were in the field at the time. Same squall line you've been chasing caused it. In fact, the accident is the reason your plane was late."

I was a little surprised. "Sounds like wind shear. Doesn't Denver have Doppler radar? Why didn't they spot it?"

"We don't know. We've even got a wind instrument array on that approach. It didn't start to register wind shear until almost a minute after the crash. And the air was probably too dry to give a radar reflection. The pilot said something about a sudden downdraft, then the plane stalled and dropped like a rock."

I nodded. "Sounds like a sudden microburst came down right on top of him. As he flew out of it, the tailwind it caused killed his airspeed."

He shrugged. "Your privilege to guess. Officially, I have to wait until NTSB says the same thing. In the meantime, I have got one senator whose grief process is just peaking in the anger phase crawling all over my ass, asking why our high-tech, high-dollar wind shear system is no damned good. I need a program."

"And I've got a program."

"That's about the size of it. Where do you stand with it?"

"We've got a plane designed; I've been flying it on a simulator, and it will definitely do the job. Take us at least a year to build it though."

"That's not a problem. Politically, we have to get something going. You've got a good head start."

"And I have absolutely no funding to get started on construction."

"What do you want to bet a grieving senator can fix that?"

"I've got a university administration dead set against me flying in anything worse than an April shower in a company plane. Afraid I'll auger into a day care center or something."

"It'll be our plane, or more likely

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NSSL's or NOAA's. On loan to your project indefinitely, perhaps. And the government will self-insure, provided you don't go off chasing funnels."

"And then there's the flight certification process."

"You have Jerry Hodge working on it, don't you?"

"Yes."

"It'll fly. You'll still have to go through the process, but it will have a high priority."

It didn't take me long to decide. Sure, it wasn't quite the project I had in mind, but it funded the tools I needed. The phenomenon I would be studying was a tamer version of a condition that contributed to tornado formation. It would also give me flight experience in rough weather, and a chance to prove out the system. Sure, I'd go along with it.

Of course, I had all the decision-making authority of a doorknob. I stuffed the ream of paperwork involved into my briefcase and headed back to the airport, wondering why this couldn't have been handled over the phone. Bloody bureaucrats!

The university administration was furious at first. They calmed down quite a bit when the FAA came up with a figure of ten megabucks "for the first phase." Well, I mean, if there's actual *money* involved, then . . . sure. Jerry couldn't contain himself. He figured that was more than enough money to build the plane and test it, too.

Of course, we failed to take into account just how much overhead a job can take once a bunch of bureaucrats find out they've got money to spend. The university blew two million putting up a fancy sheet metal (tornado bait) building down at the airstrip, and another couple of million funding a study to develop a "Severe Weather Aerial Research Foundation," and a couple of million more was set aside to staff the damned thing for a couple of years.

Which left just about enough to build the bird the way we originally intended, using graduate student slave labor, with pocket change left over for some of the instruments, and some flight training for me.

With the check came a designation. The plane was now officially known as the X-WX, the experimental weatherplane. It wasn't quite the name I had in mind, but I thought it might be bad politics to push my preference, so I settled for Ex-Wex.

When I wasn't analyzing the sparse data we'd collected that season, I was either in the basement of the Aerospace Engineering Department helping lay up fiber composites or training to fly. Jerry lined up some flight time on the University's King Air so I could log some time in a twin turboprop. I logged over four hundred hours in it, mostly instrument flying in poor weather, and I've never been so bored flying an airplane in my entire life. At the same time, I found a flight instructor with a two-seat Pitts Special and started an intensive course in aerobatics. You have not lived until you've been upside down in an open cockpit.

Jerry gave Ed some flying lessons, too. Unfortunately, the poor kid turned out to have red/green color blindness, which kept him from a Class III medical certificate. He couldn't solo or get his license. I felt like he deserved some sort

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of reward for his long, unpaid hours, so every chance I could, I let him go up as my unofficial co-pilot. I was not surprised that he was turning out to be a damned good pilot.

By the time the administration was just about ready to actually begin construction of the new facility, we were just picking the last graphite splinters out of our fingers from building the airframe. By the time the building was dedicated, we'd completed static testing the airframe, installed the engines and avionics, and were into the systems tests. We were taxi-testing the Ex-Wex before we ever occupied our new digs.

God, the X-WX was *beautiful*. I've always liked sleek, sexy airplanes, but this one was special. It must have something to do with seeing it grow from a pile of raw materials by your own hands, or take form from a pile of sketches you plopped on someone's desk. But, dammit, whatever the reason, I loved that ship like a child. So you can imagine how I felt turning it over to a professional test pilot trucked in from Edwards Air Force Base for its first flights.

I got to sit in a control tower for hours watching this guy take my baby up to see if he could make it crash, while I watched needles wiggle on a bunch of telemetry recorders. Supposedly, I'd get to learn something. What I learned was that the Ex-Wex performed *exactly* like the simulator said it would. Every test this guy was doing, I'd already done. I can't hold it against him, and he was certainly doing a good job, but why did he have to *smile* that way every time he brought it back?

He was sure the anxious little girl wasn't ready to fly it, but he finally agreed to take me up for a check ride in another plane. He had a buddy a few hundred miles away with a hangar full of warbirds. We flew up there in a Cessna 152, with him in the left seat and me fumbling to reach past his oversized elbows to the controls from the right. (If you've never flown in one, a 152 is *not* a good plane to fly in with someone you don't really like. There isn't enough room between the two seats for an ill sentiment.) I did fine, for the few minutes he let me fly, but I got the distinct impression he had his reservations about me.

This buddy of his must have been up to his ears in money. The hangar contained two Beechcraft T-34 Mentors, a battered old T-28, an F4U Corsair, and a perfectly restored P-51 Mustang. I was leaving little puddles of drool all over the hangar floor at the impractical thought of taking up one of the fighters, while my erstwhile companion was checking out the anemic little T-34s.

The owner came to my rescue. The T-34s, it turned out, were out of service waiting for parts. He suggested we take up the T-28 instead, which suited me just fine since its performance was reported to be just a notch and a quarter lower than the Corsair. We cranked up the noisy old radial, buttoned up the canopy, and took off, with little old me in the back seat looking at the back of *his* seat. If you ain't the lead mule, the scenery's all about the same.

I spent two hours back there with this guy lecturing me about all the finer points of piloting high-performance aircraft, while he had all the fun. He put the trainer through its paces, doing a full

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set of loops, rolls, spins, Immelmans, split S's and the like. He finally put it down, and seemed a little surprised when I popped out, eager to go again, without a hint of air sickness.

We gassed her up again, and this time I climbed into the front seat without asking. He went along without comment. I took the plane up to ten thousand feet, did a few gentle stalls and spins to get the feel of it, then started a little aerobatic routine I'd worked up.

"Messerschmitts at six o'clock" I announced over the intercom as I snapped the plane inverted and broke into a split-S. I nailed the throttle, broke hard right, hard left, and did a spiral roll. "One down." I broke left, dove for speed, announced "Another one behind us," and pulled up into a perfect loop. I continued the loop into a vertical climb, rolled once in the climb, cut the throttle, performed a hammerhead stall, and declared that number two had just erupted in flame as he stalled above us. I pulled out, added power, did a snap roll, and broke hard right. "Two more to the right. We're hit!" I chopped the throttles, stalled, and gave it full right rudder to initiate a spin. I let it do three full turns into an honest flat spin, stuffed the stick forward, recovered, and brought it back straight and level.

I looked back at my passenger. He was such an *awful* shade of green. I guessed he must not have had much experience in the back seat. It was a shame he didn't seem to be enjoying himself. I was having a *ball*. I just did a few dozen more stunts before I set it down.

When he recovered, he still insisted he couldn't let me fly the X-WX until we had one more certificate, but he promised me I'd have my chance as soon as it came in.

The first time is always special. I trembled as I slid into the cool front seat, while my buddy, the test pilot, strapped himself into the rear. The instruments and controls were so *new*. By comparison, every other plane I'd ever flown was a battered wreck. It smelled of epoxy and paint. I primed the nose engine, goosed the starter, and hit the ignitor. There was a soft pop, and the engine whined to life, shuddering softly as it spun up, then settling down to a deceptive smoothness only a turboprop can give. The rear engine followed suit. I'd done this dozens of times in the taxi tests, but this time it would be for real, and my whole body was buzzing with the kind of sense-numbing excitement that makes you forget what you're doing.

I finished running through the checklist as I waited for a couple of light planes to clear the taxiway, then glided on down to the stop line. One little Piper on final landed and turned off the runway, and it was my turn. I eased onto the runway and lined the nosewheel up on the centerline. Prop pitch shallow, check the gauges, throttles forward . . . oh, my God, what have I *unleashed?* It felt like I'd just been launched from a catapult.

No amount of simulator training could do it justice. I was above the pattern in seconds, way over my target climb out velocity and still accelerating, busting half a dozen limits I knew better than to bust. Thankfully, the landing gear had been designed for abuse, because

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the book said I should have tucked it up fifty knots ago. I eased off on the throttle and rpms, got my act together, and tried to remember how to fly. First lesson, this is not a 152. Never mind what the *Flight Training Handbook* says, you do *not* need full throttle to get it off the ground.

And I proceeded to find out just why the test pilot kept smiling that way.

Shortly after we finished testing the Ex-Wex, I was invited to bring it down to a fly-in in Texas. Ed's graduation was coming up, and he hadn't had a chance to fly the machine he'd put so much work into. He also hadn't gotten any job offers from simulator companies, and was feeling a little depressed. I figured he could use a little cheering up, so I invited him along. We loaded a couple of overnight bags into the storage bay, gassed up, and took off for the heart of Texas.

Jerry and Dr. Lyles, not wanting to miss the debut of their pride and joy, took off right behind us in Jerry's Beech Baron, carrying support gear for the Ex-Wex plus the computer with Ed's simulator program and a portable simulator console.

Oh, do I ever love a fly-in, especially in an area with a lot of rich old World War II and Korea vets. There were Mustangs, Corsairs, Wildcats, a Mitchell, a T-33, a Sabre, and even a MiG 15. There were also the ever-present Pitts Specials, Stardusters, Chipmunks, Mentors, and their peers. They were all interested in a new form of competition rather like the laser-tag kids play. Except that this one involved real lasers.

The technology was borrowed from the military's fighter training program, along with rules of engagement designed to minimize the risk of midair collisions. You could only shoot from an opponent's rear, and only at a range of 200 yards or more. Observers on the ground warned if you were too low or too close, and disqualified you if you violated the limits. I watched the competitors and listened to them rave about it. Obviously the limitations didn't dampen the fun. Then one of them asked me why I hadn't signed up.

I was dying to, of course. I doubted my mentors would approve, but it turned out Dr. Lyles and Jerry thought it would be a great way to show off our performance. I entered the Ex-Wex in the unlimited class, and took it into combat against the Warbirds. I took out my first three opponents in less than a minute each, hitting their kill sensors from the rear quarter with a few milliwatts of monochromatic light. Boy, was I some kind of hot stuff!

My fourth opponent, flying a Mustang, took me out in half a minute. I stared at the flashing red strobe on the pod mounted on my left wing in disgust. A few minutes earlier I had been well on my way to becoming an ace. Now, I was only another dead pilot with three kills.

I landed and sulked back to the hangar where Jerry was waiting. He could tell how disappointed I was, not that I was making any attempt to hide it.

"Cheer up," he said. "They tell me you were shot down by one of the best."

"Shot down is shot down," I replied. "There really is no excuse. The Ex-Wex is a better plane than the Mustang. The pilot just isn't worth a damn."

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An old-timer nearby chimed in. "Nonsense, you did fine. You just got matched up against Tommy Branterson earlier in the shootoffs than you should have. He used to fly with the 357th fighter group back in '44. I understand he had twelve victories against the Germans."

I met my killer later, after he'd mopped up the skies and taken the championship. He was the sweetest old grandfatherly type you'd ever want to meet, with wire-framed glasses and a pipe full of the kind of aromatic tobacco that grandfathers smoke. It was hard to picture him as the efficient ice-blooded warrior folks had been telling me about.

"Sorry about that lucky shot I got off at you," he apologized as he offered his hand. The tape from my pod said it was more like a lucky forty-two shots. "And don't worry too much about getting shot down. I watched it happen for real to Chuck Yeager, *twice!*"

Twice, huh? Suddenly I felt a little better.

We talked about planes for hours. I let him sit in the cockpit of the Ex-Wex, and he returned the favor in the Mustang. Neither one of us was free to let the other fly, although we'd have done it in a minute if it wasn't for a pile of insurance regulations. We could do the next best thing, though. I led him over to our table at the end of the hanger, coaxed the folks waiting in line to try their hand at the simulator to let Tommy butt in, and sat him down to show his stuff.

He put on quite a show, delighting the spectators with some of his best maneuvers. I smiled politely and recorded every move he made on hard disk. I'm a *sneaky* bitch at times.

Tommy Branterson turned out to be the president of an avionics company that was building simulators for Navy jets. Ed flew home with a new job offer. If I hadn't strapped him into the back seat, I suspect he would have flown home without the plane.

•

The work for the FAA was hardly uninteresting or unproductive. It was logical, systematic, safe, and even a little challenging. And interminable.

According to the rules we'd drafted, we were never to go near supercells. The FAA was primarily interested in marginal flying weather with small, scattered thunderstorms. These storms usually consist of one or more columns of warm, moist, rising air in super-adiabatic conditions. That's science talk for "the air cools as it rises because it expands, but it doesn't cool as fast as the air around it cools due to increased altitude, so it keeps rising." (Which explains why we invented a five-dollar word for it.) Eventually the effect dies out, but inertia and pressure from below carry the rising air even higher, making it even colder. Little storms tend to die when they build up a load of heavy, cold air on their tops. Just when you think they're dead, some of the cold air dumps over the side and hits the ground like a handful of flour, spreading out from a central point. The downward spill is called a microburst, and the spreading causes a radical change in wind velocity with altitude which is called wind shear. Wind shear is fairly harmless to big planes at high altitudes, but these low-altitude surprises can

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catch a plane on final approach and put it into the ground before the pilot can react.

I stalked one little baby thunderstorm after another. I stalked them up their left side. I stalked them down their right side. I looked them in the eye. I poked them in the butt. I flew over them. I flew under them. When the tops didn't exceed the limits imposed on us, I even ducked into them. Never once did I catch sight of a tornado, or even an itsy little wall cloud.

Boy, did we learn a lot about baby thunderstorms. We mapped those little suckers so much we hardly needed the supercomputer team anymore. There was not much need to model something when we'd already seen about every possible variation of it.

We gradually learned what we set out to. We got so we could spot where microbursts would spill out of a cell. We began to train Doppler radar operators on how to spot cloud shapes that predicted these atmospheric flyswatters before they could catch any planes. After about five years of this stuff, we had such a good handle on low-level wind shear, even the FAA figured we knew what we were doing.

Through it all, neither the Ex-Wex nor I felt our limits taxed. The plane had been designed for far worse conditions, and I was absolutely sure I was ready to move on. That was not cocky bravado, it was experience and professional confidence. I was no longer a raw amateur looking for adventure, I was a seasoned pilot with close to five thousand hours of experience, over two thousand of which was in weather bad enough to ground most planes.

I was also managing a little recreation each winter under the guise of public relations. The next time I met Tommy Branterson, I shot his britches off. I then proceeded to thoroughly embarrass a jet jockey in a Sabre when I pulled six gees into an Immelman and tagged his tail as he passed over me. He had no idea something with props could *do* something like that.

I wrote one proposal after another, begging for a chance to prove my ideas about tornado research. I wrote revisions to the Severe Weather Experiment Aviation Rules. (You work it out.) I pointed out our experience and safety record. I pointed out the potential benefits. I pointed out our accomplishments. I pointed out one thing too many.

Yup, someone finally figured out we'd accomplished just what we'd set out to do, all right. We got this big, impressive envelope from Mr. Keitt one day, congratulating us on the fine job we'd done, and saluting us for all the lives we'd no doubt saved. Then it announced that our funding would be cut off cold at the end of the thunderstorm season. Thank you for your services, and goodbye. We could keep the plane.

In a way, it was hard to blame them. After all, the FAA figured it already *had* a pretty good handle on tornados. Anyone who flies anywhere near the kind of storm that makes cyclones gets their license pulled for stupidity. Mobile homes aren't their bowl of rice. I understand.

But, gee, did it burn me up the way my own Alma Mater treated me. Here I was, a Doctor of Meteorology and Assistant Professor, and I *still* didn't get

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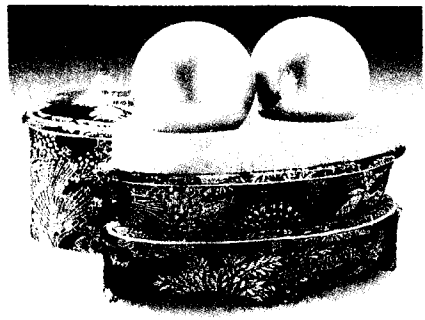

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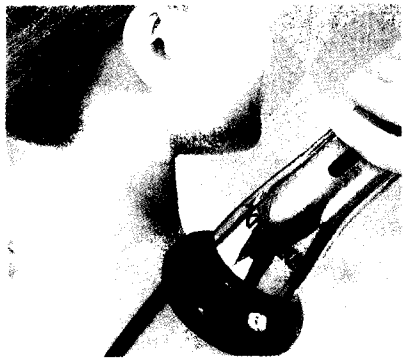

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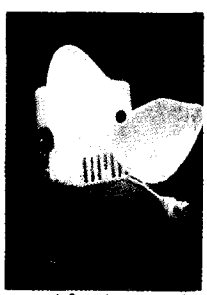

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no respect. No federal bucks equals no program and no gas money. They took over the building for a dairy science department warehouse and grudgingly allowed me hangar space in a corner behind the obsolete milking machines where I could mothball the X-WX. Under a leak in the roof.

The next tornado season found me in a van again. When the storms were active, I drove like a demon, and when they were not I wrote like a demon. I wrote papers. I wrote letters. I wrote proposals. I begged unashamedly. It did no good.

Several things were running against me. First, it was widely perceived that, since tornados were unstoppable, research into predicting them would make little difference in property damage. Second, the loss of life, while serious, was small compared to a lot of other problems the government could be spending money on. Third, there was an almost universal trepidation about the danger to innocent bystanders of deliberately putting a thousand horsepower and a thousand pounds of jet fuel in the air under such conditions. Fourth, a lot of people considered me completely over the edge, and therefore not a particularly useful observer for scientific purposes.

The season went by, and the next. We gathered little useful data. The computer modelers eliminated one promising model after another. The very complexity and instability of the phenomenon made initial guesses as to what caused tornados to be problematic. In essence, the events were singularities, sharp peaks whose locations in the mathematical continuum were profoundly affected by little changes in the initial conditions. One small bad assumption was enough to blow the mathematical model, and we were sure we were missing several major, critical pieces of data. We were looking five to ten thousand feet too low.

Meanwhile, down in Oklahoma, NSSL finally succeeded in getting Toto, the drum full of tornado instruments, inside a tornado. They found it three months later in the bottom of a cattle pond half a mile from where they planted it, its data destroyed.

Early in the third season after my grounding, the weather satellites showed a line of storms coming through with tops as cold as any ever recorded. They were estimated at sixty-three thousand feet, and the jet stream was cutting right into them about two-thirds of the way up. The combination guaranteed enormously powerful segregated updrafts and downdrafts, the conditions which lead to long-lived supercells and lots of tornados, including a high probability of killers. Funnels were being spotted at an alarming rate.

We cut into the path of the storms, positioned ourselves for the chase, and held on for the ride. The storms came through like a wave of nuclear bombers, raining devastation across the midwest. We gave chase as they passed over, and followed until they outran us. It was all over in twelve hours, and we got as much good data as we ever had, with a dozen good, close encounters. For a change, we were close enough to try releasing instrumented weather balloons, and we picked up a smattering of aerial data.

Reports were coming in of whole

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towns wiped out, so we delayed our return home to see if we could lend a hand. We stopped at what had once been a town, dropped by the Red Cross aid station, and were assigned to help dig out a demolished school.

I've never been so heartbroken in my life. Knowing the severity of the storms approaching, the residents of a trailer court had evacuated to the school, which was as tornado-worthy a structure as you are likely to find anywhere, complete with a well-equipped storm cellar. The rogue twister that hit it didn't care. As it flattened the building, it broke a twelve-inch water main, dumping a hundred thousand gallons of water into the underground shelter before the trapped inhabitants could do anything about it. We helped pull out 122 bodies.

The best therapy for something like that, we were told, was to save some lives. We were shuffled down the street to help dig survivors out of collapsed homes. I found myself working with a middle-aged fellow who was cutting into the rubble with an intensity that made me wonder if he had a loved one buried in there. He hardly spoke a word, except to bark directions to me when he needed something shored up. Something about him said he was an outsider. Despite his day's growth of beard, mud-caked jeans, and the body odor of an ox, he seemed sort of ivy-league. Nevertheless, he handled a chain saw with the skill of a surgeon, and I could tell by the care he took that this wasn't the first time he'd excavated shattered dreams.

We worked together until noon the next day, and successfully pulled seven reasonably intact, breathing humans and a litter of kittens out of the rubble. We found no more bodies. By that time, there was more help available than the Red Cross knew what to do with, so we staggered back to the shelter for a break.

We sat together (by this time I smelled at least as bad as he did), sipping cups of hot soup, and finally had something to talk about besides dangerously unstable two-by-fours. He quickly deduced I was a tornado researcher.

"You're with NSSL?" He seemed genuinely interested.

"Only peripherally," I replied. "Just a bunch of lunatics from a college down the road who're following their lead, actually. There's a fair amount of local interest in twisters, you understand."

He nodded. "I'll bet. It's something of an interest of mine, too."

I thought it might be time to finally introduce myself. I stuck out my hand. "Susan Denton. And you?"

He took my hand in a powerful, yet slightly restrained grip. "Bud Purcell, Midwestern America Life and Casualty," he responded. "Denton. I know that name from somewhere. I think I've read some of your papers."

I was flattered. A lot of fiction authors rarely meet someone who's read their stuff. Academics almost never meet someone in the public who reads research material. I was also curious about an insurance salesman who read meteorology journals. "I suppose some of your clients were caught here?"

He almost answered, looked puzzled, then smiled. "Yeah, I guess they are. Actually, I'm not an insurance salesman, exactly. I'm sort of with a disaster response team. We started sending top officials in to settle major disaster claims

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quickly some years ago. When things are really bad, sometimes it makes more sense to start digging than to set up a tent and write checks. You'd never know it, but I'm chairman of the board."

I was impressed, even if it was probably mostly public relations. "Good service!" I replied.

"Now, quit distracting me," he chided. "Something you were up to intrigued me, something really different. Aren't you the Dr. Denton who was flying wind shear studies for the FAA?"

Bingo. This guy was my buddy for life. "That's me!"

"I know it's crazy," he apologized, "but have you ever considered using that plane of yours to study tornados?"

Buddy for life? Hell, right now I wanted to have his *baby*. "That, darling, is exactly what it was designed for." I don't remember if I actually *said* that, but I distinctly remember *thinking* it.

And so out spilled the whole, sordid story of the X-WX project. But you know that already, so I'll skip it and pick up with the good part.

He seemed really excited by all this. "You know, you folks have been going about this from the wrong angle."

"That's what I've been trying to tell everyone," I responded.

"I mean you, too," he said to my shock. "Your whole interest has been in trying to *predict* when tornados will strike and what they will do. I think you should be trying to *stop* them, or at least *steer* them."

This guy was crazier than *me*. It took at least four beers apiece to get a discussion of stopping tornados going in the meteorology department.

"I'm *serious*," he went on, noting my expression. "Your own papers show that tornados die due to the very phenomena that create them. I believe your theories indicate that cold air spilling out of the storm blocks the supply of warm air that feeds them, correct?"

"Yeah, but—"

"So you don't have to choke the tornado itself, just deflect some of the cold air responsible for forming it in a way that poisons the process."

I thought that over for a minute. "Now why didn't I think of that?" And then I remembered why serious, sober discussion never had gotten that far. "You realize, of course, that there has always been a big problem with weather modification experiments. Ages ago, people experimented with cloud seeding. Every time they succeeded, they got sued for flood and erosion damage."

"Sure," he replied with a big smile. "There was even some talk once of trying to steer hurricanes, which was quashed for about the same reason."

"So how is this different?"

"I'm an actuary," he explained. "I know the risks, and I know the costs of the risks. I'm sure you know this, but just 2 percent of all tornados cause two-thirds of the deaths. What we need to do is identify where those are likely to occur, and kill them before they hatch, or at least before they can do any real damage. Your studies show that a mesocyclone capable of producing a tornado only does so about half the time. All we are doing is damping out a freak event that doesn't have to happen and which nature will never miss. Just let the energy dissipate harmlessly in the

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mesocyclone without forming a useless twister."

"But, it's not that simple," I insisted. "If you do *anything* to the storm and another twister pops out of it and does some damage, they'll claim *you're* responsible. It'd be even worse if you just made it veer into something else."

"Lady, remember who you're talking to," he chided. "I'm the insurance industry. I'm *always* responsible. When a tornado sucks up a town and makes it look like it's been in a food processor, I get to buy a new town. If I've got a choice between saving a town and saving Farmer Brown's tin roof, Farmer Brown sure as hell better take cover. Let him sue! Everybody else can worry themselves sick over lawyers. From where I sit, I can see a real simple bottom line. I can save a town and save a bundle or I can avoid a lawsuit. I'll take the cheaper course every time. And if I can save a couple of hundred lives in the bargain, then I don't have to pay out of the life insurance fund, either."

This was from the same guy who, a few hours earlier, had thrown his body under a shifting timber rather than risk the house collapsing on a seven-year-old child. He could have been seriously injured. I suspect I would have jumped clear.

"So what I'm asking from you," he went on, "is enough information to let me make a sound fiscal decision. First, how much will it cost to find out if this approach is possible? Second, what will it take to put that information to work?"

I realized he was waiting for answer number one. I thought for a minute. I hated to scare him off with the considerable costs, but it would hardly pay to sucker him in with an unrealistic estimate. I gave him the straight poop. "We already have the plane, so all we need is an operating budget. The plane costs about two thousand an hour to operate, and I could probably fly, say, five hundred hours a year. That's a million dollars. I don't yet have all the equipment I need for twister research, either, to the tune of about two hundred kilobucks. Plus, I need support from a lot of government agencies, and I still work best with a ground team. And we may need to buy a considerable amount of silver iodide to experiment with cooling the updraft."

"How's two million a year sound?" he asked, matter-of-factly.

I was dumbfounded.

He shrugged. "It cost me nearly two grand an hour to fly the company jet down here. Your estimate sounds reasonable to me. I want results, and I don't expect to get them cut-rate. I'll get you more if you need it. Save one town the size of this one, and you'll pay me back fifty times. Besides, I intend to get some help paying for it from the rest of the industry."

"But what about the—"

"And don't worry about the government or any other bureaucratic meatheads. I know how to kick butt."

By early fall, we were flying again, if only to prove out new equipment. All winter we beefed up the technology. I got the Bendix/King Vertical Profile weather radar I'd always wanted, modified to our special requirements. We finally got approval on the chaff rockets, the design for which had been enhanced to produce smoke. The government

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pitched in some tiny transponders that fit in the rockets and returned pressure and temperature data. We fitted the back seat with a thermographic video camera that tracked my head movement and could be locked to hold attitude by a button on the joystick. By the time the next season rolled around, we were ready for the hunt.

The government didn't go along easily, but money finally talked. The prospect of actually killing tornados instead of merely predicting them intrigued even the bureaucrats. They agreed to a pilot program, on the condition that I do the flying well away from populated areas. That cramped my style a little, since I preferred to be in range of Doppler radar from a major airport, but I supposed I could live with it.

So in late February, I finally broke out a kit of stencils I'd been saving for years, and sneaked down to the hangar in the middle of the night. By morning, the X-WX had its new namesake painted on each side of the nose: a Swainson's hawk holding a writhing tornado in its talons. Ex-Wex had a new name, the Funnel Hawk.

We headed south the next day to catch the tornado activity that usually started early down there. Spring tornados in Texas are often long-lived, and we planned to exploit that fact to get plenty of data on active funnels. We would then follow the bad weather as it moved north into Tornado Alley. April is known to produce particularly nasty twisters especially in central Oklahoma, the home of NSSL.

I stalked my first tornado in the second week of March. I was tracking a line of suspicious-looking cells, and spotted it as it dropped from a wall cloud about forty kilometers from the plane. I skirted it cautiously at a range of about fifteen kilometers, dropping chaff and trailing smoke. We fired a pair of rockets in its general direction to test the data gathering system. The data on that first funnel was sparse due to the range, but it was good enough to let us plan a closer flight the next time.

Later that day, we came in to ten kilometers for a second funnel. The air was still fairly calm at this range, in fact, I could easily have handled it in a light plane. We fed the new data to the computers, and confirmed a stream of warm air was gently wafting toward the mesocyclone from just above ground level off the right trailing quarter of the storm.

We did a series of three flights at a range of five kilometers on a new line of storms a week later. At this range, the flying was starting to get a little more interesting, but it was still no great challenge, even compared to the earlier wind shear studies. The winds at this point were considerably better defined, faster, and starting to lift upward from the ground. We were also close enough to begin looking for expected rear flank downdrafts. These could be the key to strangling a twister, but could also be a factor in triggering it. Doppler radar was in range of two of these storms, but not close enough to track the chaff for anything but qualitative data.

Two weeks later, I got in two more flights, this time at three kilometers. Those were a little more interesting. Skirting around the mesocyclones, I encountered wild reversals in wind direction, first getting slapped down by rear flank winds, then inward toward the

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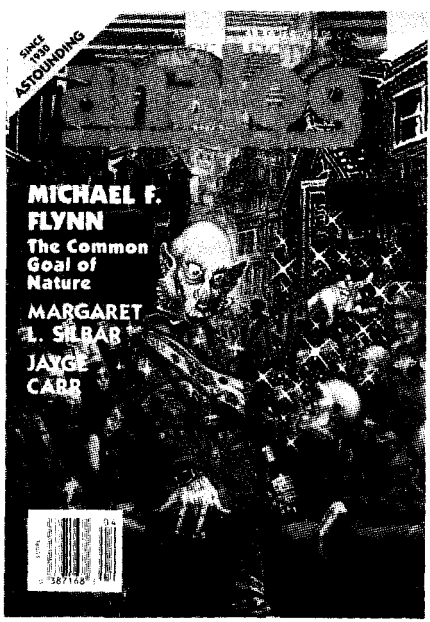

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storm by main inflow, then in and down. At this range, I was close enough to get good use out of the rockets, getting four inside each twister at various altitudes from the funnel itself to way up in the mesocyclone.

The time for studying existing funnels was coming to an end. The twisters were becoming shorter-lived, more erratic, and more powerful as the season wore on. An expected concentration of vicious twisters in Oklahoma would be our next target, with the idea being to survey as many supercells as possible, so that we could get a better feel for their structure, and determine which ones were likely to drop funnels.

So it was that late April found me 120 kilometers southwest of our temporary base airport, out over open prairie, looking at a trophy-sized thunderboomer towering up out of a line of squalls. Oh, my, was it ever a lovely textbook example of a big, mean, anvil-headed supercell. It was sixty thousand feet tall, its top icy cold, dropping tennis-ball-sized hailstones all over the grazing land below while it sucked up the late-afternoon heat from the ground to feed itself. Its line was taking it straight toward the airport, yet I was safely out over cow-country, with nothing to fall on but line shacks and hoofy critters. Considering the beast had blundered into range of the brand new NEXRAD radar facility at the airport, the opportunity was simply too good to pass up.

"Funnel Hawk X-WX to tower, I have the main updraft in sight. My idea of *perfect* flying weather," I said into the microphone on my classy new jet fighter-pilot helmet. I checked the VP radar. "I get no sign of rotation in the main updraft. How about you?"

The radio crackled a bit as lightning flashed in the heart of the storm. Dr. Lyles broke through. "Roger, Hawk, we confirm. We see a possible wind shear at eight thousand feet directly behind the storm. Check it out."

I backed off the throttles and pitch and took it down. As I crossed ninety-two hundred feet, I felt the buffet of a sudden change in wind speed, turned on my smoke, and dropped a chaff packet. I looked behind me to see the pattern. "You're a little low, tower. Hawk has confirmed wind shear and a horizontal spinner in clear air at ninety-two hundred feet and three kilometers astern of the main updraft. Chaff away."

I spun up the props, nudged the throttles, and followed the horizontal vortex across the back of the storm, dropping chaff along the way, then peeled off to take a look-see with the radar. Within minutes I saw the vortex catch up to the storm and start to pull up into the updraft. Almost immediately, the updraft began to turn gently from the bottom of the cloud. Over ten minutes, the swirl intensified, and spread to the top of the storm. Updraft speeds were up to a hundred and fifty feet per second.

"Hawk to tower, we've got a full-blown mesocyclone here," I reported. I noticed a cylindrical formation at the base of the cloud. "I think we've got a wall cloud forming. I'm going down for a closer look."

"We see the meso, Hawk. Be careful, looks like a big one."

I dipped the left wing and spiraled down around the rear of the mesocyclone, taking readings as I went. I was

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in a cold mass of air that was dropping from the heights of the storm. As I neared the base of the cloud, the turbulence increased. The cold air was piling up against the rising warm air, something I hadn't quite expected. This was interesting. Punching a hole in the dike might be the weapon we needed to cool down the updraft before a tornado could form.

I dropped below the cloud and reversed my direction around the wall cloud. "Tower, this is Hawk. I'm dropping more chaff. I'm getting no indication of consolidated inflow or rear flank. Do you confirm?"

"Hawk, we confirm. How's the circulation look to you?"

I studied the poorly-formed wall cloud from underneath. "This thing's not ready to hatch yet, tower. I've got a really good chance to watch one form here. I'm ducking underneath to take some readings before the feeder winds develop."

"Watch it, Hawk. That thing's got some power."

"Definitely a Roger, tower. I'll just circle under the wall and spit out some chaff. I want to get a good record of what sets it off if this thing wakes up."

The air under the wall cloud was calmer than I'd expected. From under its belly, I could see the mesocyclone circulating slowly, but it seemed to lack organization. I was flying in air that was rising vigorously, but had little spin and none of the features that we were expecting would trigger a twister to develop from the supply of rotating energy towering above me.

I completed my circuit of the wall cloud. "Tower, if you still see no consolidation, I'm going to dip down and try to get a radar and thermal snapshot from underneath this thing."

"Roger, Hawk. Your chaff echoes show it's still sort of tame."

I dropped down to six thousand feet, increased power to maximum, and pointed the plane up toward the middle of the mesocyclone. I set the videocamera to look forward, then locked the gyros to keep it pointed that way. The color VP radar screen showed a writhing red mass that looked like something from a science fiction movie. Such things invariably devour starships, I reminded myself. I peaked my arc at eight thousand feet, well short of the center of the circulation, and turned sharply to head back toward less treacherous air.

"Um, Hawk, this is tower. *Please* get out of there."

"Data in the bag, tower, and I'm already heading ouuuuuuu . . . Whaaaaaatttt tttthhheee huh huh huh uh uh hellll?"

The clear air reached out, grabbed the plane, and twirled it like a baton while simultaneously kicking it around like a soccer ball. Centrifugal force slammed me forward against my safety harness, and my head whipped down within a couple of centimeters of the joystick, which was beating wildly against my left knee. My rudder pedals were locked full right. I tried to pull the controls back to a sane position, but I might as well have tried to pull a crowbar out of concrete. From deep within the plane, I heard something snap.

"Hawk, Hawk . . . you OK? We've . . . telemetry and we've . . . strong hook over . . . location." The tower's signal faded in and out about twice a

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second, probably as the antenna was blocked by the fuselage. Although the seat of my pants said the plane was holding fairly level, my inner ear said it was spinning like a top. I couldn't hear clearly anyway over the high-pitched screech of air being sucked from every crack and crevice of the cockpit.

I struggled to reach the comm button on the joystick. I thought I'd pressed it, but all that happened was a thump and a whoosh from my right. I struggled to raise my head, and caught a "ROCKET LAUNCH" indicator on the instrument panel.

My ears were popping from the rapidly decreasing cockpit pressure. I was vaguely aware of a stream of cold, dry oxygen entering my left nostril from the nasal cannula I wore in place of an oxygen mask. At least *that* was working. I'd never seen a crash like I was about to have, and I certainly didn't want to miss it due to anoxia!

Suddenly the joystick slammed full back, and the rudder pedals reversed. My torso flew back against the seat, and my head slammed against the headrest, giving me a very good, but highly unusual, view of the ground. Something went snap again, this time apparently from around the right wing root.

"Hawk, Haw . . . read me? We . . . definite funnel . . . location. Over."

I fumbled for the comm button, and this time connected with it. "Don't bug me, I'm sorta busy."

I was busy trying to point the plane at something besides the ground. I needn't have bothered. In the first place, I had absolutely no control, and in the second place, the altitude was increasing briskly, not that I had any way of knowing it. The barometric altimeter was pegged at its maximum reading of sixty thousand feet, and the radar altimeter declared I was off in space somewhere, which was hardly surprising since that's where it was pointed. Since I was close enough to the ground to just about make out individual cows, I suspected both were in error a bit.

Now, that in itself was interesting, I realized. I could see the ground quite clearly. The twister that had me still hadn't touched the ground, and wasn't pulling in any rain. Even so, a twister is usually clearly visible as it descends from the mesocyclone. I considered the possibility that I was right at the tip of the funnel, being spun at the ground like a drill bit.

I heard another snap from the right wing, and *really* wished it would quit doing that.

What the hell, I thought, might as well get some work done while I was here. I released a couple of chaff packets and another rocket.

"Hawk . . . read me? . . . all right Susan? . . . dispatching ambulance."

That was mighty nice of them, I thought. Where did they plan to meet me?

"Tower, this is Hawk. Just released some chaff. Let me know what it does. Tell me where I am."

"Hawk, you're . . . steady at . . . thousand feet. Mode C . . . useless. You're . . . stationary. We . . . chaff. Thought . . . broken up."

The plane suddenly stopped spinning so violently, changed attitude radically, and began to pull negative gees with the nose pointed slightly above the horizon. Looking down the left wing toward the

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ground, I could see the nearly transparent tip of the twister dropping away from me. I was definitely getting a unique view of this thing from the inside. Semi-consciously, I swung the video camera around to take in the spectacle. The twister dug into the prairie like a kamikaze, and the funnel began to darken rapidly from the ground up. I dropped a couple more chaff packets.

"Say altitude again, tower."

"About niner thousand feet, Hawk. Repeat . . . feet and climbing."

Well, at least the rate of rotation was down to about once per short sentence. Now if only I could roll this thing over to get positive gees. I found I could now move the controls a little against the back pressure, but I found no correlation between my movements and the plane's response. Except that moving the stick to the left caused a cracking noise.

I was looking back up toward the cloud, when suddenly the visibility dropped to zero. With nothing to look at outside but bits of prairie vegetation going by at about two hundred knots, it suddenly occurred to me that it had been a while since I had scanned the instruments.

I found some interesting readings soon enough. Exhaust temperature for both engines was virtually zero, fuel flow was minimal, and torque was nil. So, despite the convincingly furious windmilling of the props, I had no power. Both powerplants had flamed out, and I hadn't a clue over the incredible racket of the twister, which had now turned from a screech to an unusually low roar.

"Hawk, your present . . . feet, repeat twelve thousand feet. Please acknowledge."

"Still here. Engines out," I heard another cracking sound from the right wing, "and I may have structural damage. Still holding together so far." I reached to release another chaff packet, then decided it would probably give them a heart attack right now. Besides, there was plenty of muddy debris in the funnel by now that would give a radar reflection.

Theoretically, the plane had enough power to pull its way out of a twister, based on the average wind speeds of less than two hundred and fifty knots our measurements predicted. However, the pressure altitude was reading somewhere on the fringes of space the last time I checked, which was too low to burn a turbine. I looked at the barometric altimeter again. It was registering twenty-three thousand feet. I wasted no time in trying a restart of the front engine.

The engine balked through three attempts, then caught on the fourth try. The rear engine caught on the second. I nursed them gently as they surged and fought the rapidly varying winds around the plane. When they looked like they were burning evenly, I eased the throttles forward. To my amazement, the controls responded. I rolled the plane over to a more natural attitude, putting the gees back in the seat of my pants where they belonged. I checked my electronic orientation device, figured out which way was up, and mentally plotted a course out of the storm. I eased the throttles forward to the stops. The fat props bit into the wind and began pulling me with deliberation.

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I broke free from the funnel suddenly, but not into the relatively bright sky I was expecting. The plane started falling like a rock, out of control again. I glanced at the instruments. The rate of climb indicator needle was actually bent against the up stop. The altimeter was spinning like a propeller and then stopped suddenly at sixty thousand feet. The engines were flamed out again.

Outside the canopy, I could just make out three black columns snaking around me. They converged at what I took to be the ground, and it was coming up fast. I recognized the situation instantly. I was in the center of the main funnel, surrounded by three Fujita suction vortices, being pushed toward the ground by an intense downdraft. I fired off a pair of rockets immediately.

I flailed helplessly at the controls for a couple of seconds, then felt a little back pressure from the elevator. Without really worrying about where I was going, just as long as it was away from straight down, I pulled up like crazy. The nose veered a little, not enough to keep me from digging a crater, just enough to edge me back into one of the three small twisters trapped in the big one with me.

Hitting the little funnel put me back where I had been earlier, except that this time I was so close to the ground the plane was being pelted by sizeable rocks. I wasn't sure where I was going, except that my direction had changed violently from what it had been, accompanied by a really loud snap from the right wing.

I restarted the engines again, but this time kept the throttle just high enough to allow some control of the plane. I checked the electronic orientation indicator, got my bearings, and rotated the plane to a stable attitude. I concentrated on climbing while staying in the relative safety of the little funnel. The odds there were better, I figured, than attempting another breakout this close to the ground.

"Tower, this is Hawk. This thing is a triple Fujita. Do you copy?"

No response. I turned down the squelch.

"Tower, this is Hawk. I'm in a triple, repeat, a triple. Almost stuffed me into the ground."

Nothing came back over the radio but static from the lightning bursts of the storm and the peculiar radio hiss that tornados generate. God, was it lonely in there.

The plane was climbing slowly, I guessed. The barometric altimeter was still giving an improbably high reading due to the low pressure inside the funnel, but it seemed to indicate a slow ascent. The best evidence was that the rocks banging against the plane were getting smaller. The really big ones were simply being pitched out of the storm as centrifugal force overcame the ability of the wind to make them turn.

"Tower, this is the Funnel Hawk. Do you read me?"

Again, there was no response. I waited.

"Hawk, we have your mode C code. Do you read?"

Boy, did that sound good. "Hawk here. Engines running, back under some control. Where am I?"

"Hawk, you're at four thousand feet and climbing, as near as we can tell. Repeat, four thousand feet. We're get-

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ting reflections from what appear to be several funnels in there with you."

Now they tell me. "Confirmed, tower, this is a Fujita triple. Three little suckers with a big, nasty downdraft in the middle, just like we figured. Any recommendations on how to get out of it?"

"Negative, Hawk. Suggest you hang tight if you can. You are now at five thousand feet. Your storm is in sight of the airfield. We see your funnel."

Big help *they* were. I hung tight, watching the outside temperature gauge and listening to the right wing crack. I wondered which would last longer, the twister or the twistee.

And finally, there it was, the drop in temperature that theory said had to come sooner or later. I felt the funnel loosen its hold on the plane, then die completely. The sky suddenly cleared, except for a rain of muddy bits of debris from where the funnel had been. I gasped when I saw some of the chunks that had been in there with me. There was at least one fairly good-sized tree heading back for the ground, hundreds of limbs big enough to have knocked off a wing, and a couple of twisted-up tin roofs.

The plane looked like hell, with handfuls of prairie weeds draped over the wings and empennage, messing up the carefully designed laminar flow airfoils. It still handled well enough, though. Mind you, I was *mighty* tender with the controls, considering the state I suspected the right wing was in.

The compass gradually stopped whirling around and settled down at a heading of two hundred and fifty degrees. The other instruments were starting to make some sense again. Even the attitude gyro was tentatively feeling for the vertical. I looked out at the ground to try to get a few visual references. That's when I saw it.

A shiny yellow road stretched off to the west.

I looked up to see if a house was about to fall on me.

I keyed up the radio. "Hawk to tower. We're not in Kansas anymore."

The radio let out the cheers of about fifty voices, and I couldn't make out a word Dr. Lyle said for about a minute. Finally the babble subsided. "That's right, Hawk. This is Oklahoma. Welcome home. What's your condition?"

The road ahead changed from bright yellow to brilliant orange as the setting sun peeked through a gap in the grey canopy. Four asphalt lanes of orange, divided by a grassy median. I relaxed as I recognized the highway.

"Hawk has a sore wing and a belly full of kerosene." I looked over my shoulder at the storm bearing down on the airport. "I think I'll just stay up here and burn off some fuel. You guys can play with my friend for a while. If there's anything left of you in about an hour or two, could you send a few fire trucks out to meet me on some runway you can do without for a while?"

I had plenty of time to weigh my options while the storm pounded toward the airport. I was still hearing occasional little snaps from the wing when gusts of wind hit me, prodding me to make a decision. I could just bail out, and write the plane off, but I wasn't sure what the odds were of surviving. I could find another little field around here, but if the plane broke up on landing, I'd be without a rescue team. On the other hand, if I just hung around up here, my wing could fall off and eliminate *all* my options. My reluctance to sacrifice my

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baby plus my lack of enthusiasm for skydiving won out, and I resolved to bring my crippled bird home in one piece.

The radio broke squelch. "Funnel Hawk, this is Baron November three-seven-six-zero Uniform, on your five o'clock and down two hundred feet."

I looked behind me and to my right. Jerry's Beechcraft was easing up behind me about a kilometer off. "Jerry! What are you doing up in this mess?" I remembered his description of his previous encounter with a thunderstorm, and really appreciated what it meant that he had come up to help me.

"Oh, just thought I'd come up and see what I was missing. While I'm here, mind if I take a look at that wing of yours?"

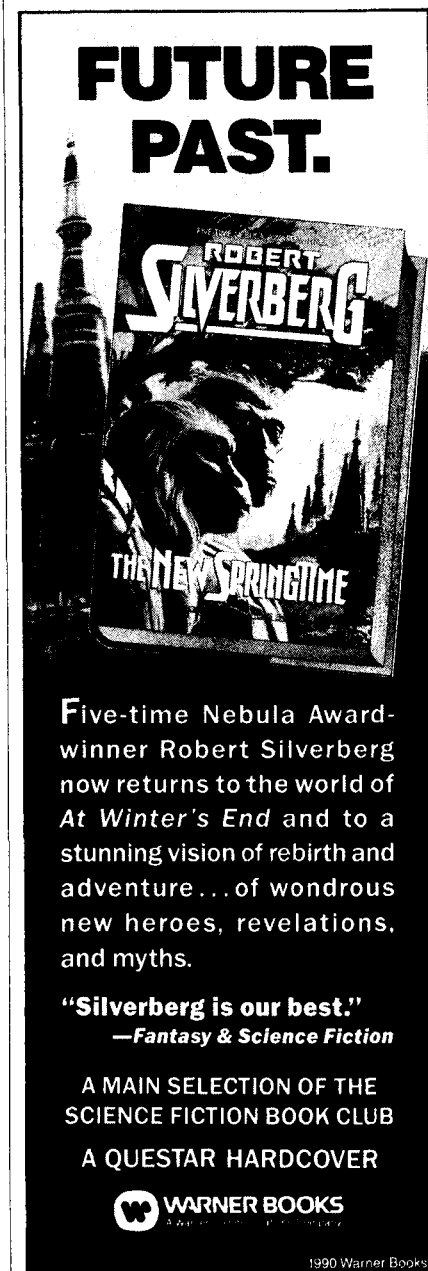
"Be my guest, six-zero Uniform, but don't get too close. One good gust and it might fall off on your punkin' haid."

Jerry eased his twin in below me, maintaining a respectful distance in the turbulent air. "Can't see a whole lot of detail," he reported. "You have a gash in the skin virtually the entire length of the wing root on the underside of the wing."

Great. Just great. The Funnel Hawk relied on the strength of its graphite composite skin for much of its structural integrity. With the skin breached, there was no telling how much the main spar inside could take. On the one hand, it had held up fine in the tornado. On the other hand, it had just been through a tornado. I toyed with the straps of my parachute.

"Jerry, can you hang around for a while? Stay down there and let me know if it gets any worse."

There was hesitation for a moment. "Do you really think that's wise, Su-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san? It'll be dark before that storm clears the airport. If you go down in the dark, there are no guarantees."

"I've got no guarantees either way, Jerry. I figure I've got better luck waiting for the best emergency facilities around."

So Jerry stayed back there. When darkness came, he turned on his landing lights and kept them trained on my wing. I held the plane *really* steady, but not necessarily to give him a good view.

A million years later, the storm cleared the area, leaving almost dead calm in its wake. The emergency crews moved into position. I dumped excess fuel and lined up on the runway. Jerry advised me to take advantage of the long runway and land with my flaps up to lessen the strain on the wing during final. He figured I could survive a broken wing on the runway a lot better than I could five hundred feet up, too low to bail out.

I made a conscious effort not to hold my breath on final. As gently as I could, I glided down to my touchdown point, rounded out, and touched the main gear to the pavement just as the stall warning sounded. I braced for a ground loop as the plane settled its weight onto the wheels.

There were a few mild popping noises as the plane slowed to taxi speed. No crunch. Not even a pronounced sag. In fact, it felt like any ordinary landing. As I taxied past the rescue team, I keyed up the mike and said, "Waiting for somebody?"

I've had a couple of weeks now to analyze the data. A couple of things have got me excited. First, I know exactly what triggered the twister. I did. The high-powered turn I made under the mesocyclone generated a small vortex that set the whole thing off. The videotapes show it clearly.

The Crays digested our data. Boy, do we know a lot more about tornados than we did before that flight. I was carrying more instruments than we'd ever dreamed of putting into a twister, for economic reasons and as a practical matter of delivering them. We still aren't sure we can tap into the cold air mass I discovered above the wall cloud, but we've got half a dozen theories we want to try.

Finally, the Funnel Hawk is fine. Some helpful soul had added an extra layer of composites over the bottom of the wing root because they thought it ought to be stronger. Since the wing had a prescribed amount of flex there, the extra fibers were seriously overstressed. They delaminated, with the loose end flapping around in the breeze, looking like busted skin. That plane has strengths it's never even explored yet. We sent the engines off for a full teardown, just to be sure they didn't suck in anything unhealthy, and the props were too dinged up to use again, which will set our sponsors back a pretty penny. Otherwise, it looks like the full airframe inspection is likely to cost about ten times as much as the actual airframe repairs.

So I'll be ready to go again in a month. While I'm finishing up the current series of studies, I've asked some friends to work out a strategy for a new program I have in mind. I figure with a couple of extra oxygen bottles for the engines, I might just be able to keep them lit reliably through the sudden pressure drop. If I can put together some silver iodide bombs, I might just try ducking into one of those brutes again sometime soon, and this time, I intend to kick it in the ribs! ■

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Geoffrey A. Landis

AIR POLLUTION ON THE MOON

1. The Lunar Ambient and the Need for Vacuum

It seems absurd to think that there could be such a thing as air pollution on the Moon. After all, there isn't even any *atmosphere* on the Moon.

In fact, a little bit of atmosphere *does* exist on the Moon. Gases get to the Moon from natural causes, by most of the same mechanisms gas accumulates on the Earth or on other planets. Carbon dioxide and argon outgassed from the Moon as it cooled down (maybe less than the Earth, since the Earth's hot core moves the continents around, forming volcanoes at the plate boundaries —volcanic carbon dioxide is the primary source of the oxygen in the Earth's atmosphere—but still *some* gas should have formed on the Moon). And random comet impacts also add some gas —nitrogen, water vapor, and various junk like that—not to mention a little hydrogen and helium deposited by the solar wind.

The Moon, however, keeps very little of the atmosphere it receives. Any gas it momentarily captures escapes from the surface very rapidly. As it turns out, there are two different ways for gas to escape from the Moon. For the light gases—hydrogen, helium—the lunar gravity is just not quite strong enough to hold it very long, and the gas simply leaks away from the top of the atmosphere. On the sunlit side of the Moon (where the gas is hottest), hydrogen and helium typically last only fifteen minutes before boiling away.

For the heavier gases, though—like oxygen and nitrogen—the gravitational escape lifetime in the atmosphere is thousands of years. While the Moon will lose atmosphere over geological time spans, it could hold onto gas for a very long time by human scales.

For these gases a different mechanism removes them from the lunar atmosphere. The unfiltered light of the Sun ionizes the gas molecules, and the ionized molecules are then quickly swept away by electric fields associated with the solar wind. This occurs in a time span of approximately 100 days. When the atmosphere gets thick enough this mechanism stops happening—but the gas generation needed to make it "thick enough" is something like 10,000

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tons/day—considerably higher than anything produced in our lunar industrial facility—at least in the next century or two.

This self-cleaning property of the lunar atmosphere (or lack-of-atmosphere) is so fast that it seems absurd to expect that the lunar vacuum could be lost by reasonable levels of human operations on the Moon. However, high-vacuum and ultra-high vacuum is needed for many industrial processes, some of which we may want to do on the Moon precisely *because* of the high-quality vacuum. For example, vacuum processes which might be simpler to manufacture or use on the Moon include vacuum tubes, semiconductor manufacture, solar cell manufacture, and particle accelerators.

But first, a quick digression to discuss the units used when talking about pressure. For historical reasons, gas pressure is often measured in terms of the height of a column of mercury that will exert the same amount of pressure at its base. This is because old-fashioned barometers used a tube of mercury to measure pressure. One Earth-normal atmosphere is equivalent to the pressure of a column of mercury 760 centimeters tall. Some of the first barometers were made by an Italian scientist named Torricelli, and so the pressure of one millimeter of mercury is called a *torr* in his honor. One torr is not very much pressure: a little over one one-thousandth of an atmosphere; far too little to even consider breathing, for example. But for processes sensitive to air, one torr is a heck of a lot of gas molecules. In the business we'd call it a "rough" vacuum (although it *is* a whole lot better vacuum than you'll get with your ordinary home vacuum cleaner).

Good vacuums ("vacua," to the pedant, but heck, why be formal?) are measured in numbers best expressed in exponential notation. Ten to the minus three torr—one millitorr, a tad more than a millionth of an atmosphere—is better vacuum, but still not great. Ten to the minus six is getting into what we'd call very high vacuum. Ten to the minus nine—one nanotorr, roughly a billionth of an atmosphere—now *that*'s getting to be a decent vacuum. A nanotorr qualifies for the range of "ultra-high" vacuum.

OK, done with that digression. I won't mention the other units vacuum is often measured in, such as pascals, millibars, microns, and so on—no need to get you confused now, right?

The existing lunar atmosphere is exceedingly tenuous: something like 100,000 molecules/cm^3 during the lunar night, and one to ten million molecules/cm^3 during the lunar day.[1,2] This corresponds to pressures from 0.001 nanotorr up to a "high" of half a nanotorr, primarily consisting of hydrogen, helium, argon, and neon at night, with the probable addition of just a hint of carbon monoxide and carbon dioxide in the daytime (they would freeze out at night, of course).

So what do we need a vacuum for? And how much do we need?

As it turns out, the reason I started thinking about this subject is that I had been doing a study about the feasibility

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of making solar cells on the Moon,[1] and I started to wonder if the lunar vacuum would stay good enough to do ultra-high vacuum semiconductor processing even after we start messing it up. (Why make solar cells on the Moon? Well, silicon happens to be a good material to make solar cells out of, and is a major component of the lunar crust. And it's about fifty times easier to lift something off the surface of the Moon than off the Earth. If we ever go in for space industrialization in a big way, we're going to need power, and lots of it. Putting the power-plant factory on the Moon is the equivalent of putting it near a major port—and one that also happens to be abundantly supplied with natural mineral resources. Anyway—) One good way to produce low-cost solar cells is by a process called plasma-deposition of amorphous silicon. Plasma deposition typically needs a background pressure in the very high vacuum range: a thousand nanotorr, to below a hundred nanotorr for some experimental set-ups.

Many other processes for manufacturing semiconductor products also require vacuum. A high-tech process for depositing high-purity compound semiconductors is Molecular Beam Epitaxy (MBE). This process requires ultra-high vacuum. Base pressure for MBE is in the range of a tenth of a nanotorr, and even lower base pressure is needed for making some very high quality materials—where carbon and oxygen contamination are particularly harmful.

"Vacuum" tubes have different values for the required operating vacuum, depending on the type of tube and the lifetime, noise level, *etc.* required. This ranges from ten-thousand nanotorr for a magnetron tube like the one in your microwave oven, to ultra-high vacuum of a tenth of a nanotorr for high-power traveling-wave tubes.

What about the Moon as a site for the next-generation high-energy supercollider? Land is cheap (and there's no problem with groundhogs burrowing and shorting electrical cables, either!); there's plenty of cheap solar energy (or there will be as soon as I build my solar cell manufacturing factory!), and cooling the superconducting magnets down to cryogenic temperatures will not be very difficult, especially if we put the supercollider at the lunar pole and run it during the polar night. Most important of all, though, the Moon has lots of cheap vacuum. Intersecting storage ring accelerators require very good vacuum, since residual gas tends to scatter and defocus the beam. At a pressure of one nanotorr the beam lifetime is typically around ten hours; and operating pressures of under a hundredth of a nanotorr are required for really good beam storage and operation. An additional problem is that whenever the beam tube is vented to atmosphere (for maintenance or whatever) gas gets adsorbed onto the surfaces. When the beam line is then pumped down and turned on, the adsorbed gas is knocked off the surface by the beam, meaning that it takes days after the beam is back up before the beam quality is really up to spec.

2. Twenty Person Base

This vacuum will be degraded by hu-

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man habitation and industrial processing of materials. Unfortunately, it seems rather unlikely that maintaining the lunar vacuum will be an important priority of the occupants of a moonbase. So now let's consider where waste gas is likely to come from.

The major contribution to the lunar atmosphere from a small exploration base is exhaust gas from the transport. Assuming a specific impulse of 400 seconds (90% of the theoretical specific impulse of a hydrogen/oxygen engine), landing on the Moon requires 0.8 tons of propellant per ton of landed material. I assume a 10-ton lander making one trip per month with 2 tons of supplies landed per person per month (including the personnel rotation, machinery, scientific and exploration equipment, *etc.*). This assumes that the lander is not refueled on the Moon from lunar oxygen, and that no payload is carried from the Moon.

In actuality, not all of the propellant gases end up contributing to the lunar atmosphere. The exhaust velocity of a hydrogen/oxygen engine is 4 km/sec, nearly double the lunar escape velocity. Further, if the trajectory used is an insertion into low lunar orbit followed by a descent burn, for much of the engine burn the exhaust will not be directed toward the lunar surface. But for a rough calculation here I assume that the entire engine exhaust contributes to the atmosphere.

Another contribution to the generated atmosphere is air leakage from the living quarters. One estimate[4] of air leakage from an advanced long-duration habitat at atmospheric pressure is 1.2 kg of oxygen plus 4.5 kg of nitrogen per person per day. It has frequently been proposed that oxygen be locally generated. If this is done, it is unlikely that nitrogen dilution would be used, since nitrogen is nearly absent on the Moon. Thus, the habitat pressure would be proportionately lower, and the leakage rate is expected to be reduced to 23% of that listed above. However, as discussed later, lunar generation of oxygen would itself be a likely source of leakage of waste gas.

In addition to this leakage, air will normally be lost during ingress and egress for extra-vehicular (or extra-habitat) activities ("EVA"). The amount of air lost will depend on whether the airlock is simply vented during egress, or if the lock is pumped down and the exhaust air reused. In the baseline case I will assume that the lock is simply vented, and there is one EVA per person per day, with an airlock volume of two cubic meters of air at one atmosphere pressure, which is somewhat less than the habitat leakage (and, like the leakage, reduced if the base is assumed to have a pure oxygen atmosphere).

A human being generates about a kilogram of waste carbon dioxide per day. I would hope that any reasonable habitat would recycle this rather than waste it . . . but it's quite possible that a *spacesuit* might not be designed to recycle the carbon dioxide, and vent it out to the surface. If the 20 person crew averages 4 hours of EVA per day, that comes out to an additional hundred kilograms per month.

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The increase in atmospheric pressure produced by waste gas can be calculated by multiplying the mass of gas exhausted times the gravitational acceleration of the Moon and dividing by the lunar surface area. Since the exhausted gas has an average lifetime in the lunar atmosphere of 100 days, the equilibrium contribution to the atmosphere is about a thousandth of a nanotorr per ton of exhaust gas per month.

Lander exhaust results in an equilibrium pressure of 0.06 nanotorr for a 20 person base, habitat leakage in a pressure contribution of 0.004 nanotorr, airlock venting 0.0017 nanotorr, and spacesuit CO_2 venting negligible.

Table 1 summarizes the contributions of the various gas sources discussed. The daytime total atmosphere is in the range of 0.07 nanotorr, comparable to the natural lunar atmosphere. (During the lunar night, some of this will be adsorbed into the soil, lowering the pressure a bit). Good—for the small base, at least, the vacuum is still OK for most anything we want to do.

3. Two-hundred fifty Person Industrial Facility

If industrialization takes place on the Moon, it could be expected that the lunar habitat may have hundreds of inhabitants, and considerably more frequent resupply flights. In this case, the vacuum degradation will be correspondingly worse. The baseline calculated here will be for a 250 person base processing oxygen from lunar soil.

I assume here slightly less support

Table 1: Contributions to Lunar Atmosphere

Source	Contribution (nanotorr)	Notes
20 Person Base:		
Propellant	0.06	*50 ton lander; all exhaust gas contributes*
Habitat Leakage	0.004	*6.7 Kg/person/day*
Airlock losses	0.002	*$2m^3$ vented; less if pumped down for EVA*
Total	0.07 nanotorr	
250 Person Industrial Facility:		
Propellant	0.6	*Refueled using lunar oxygen*
Habitat Leakage	0.05	*6.7 Kg/person/day*
O_2 Production	0.9	*500 tons produced per month; 25% leakage*
^3He Mining	0.9	*10 tons produced per year; 25% leakage*
Industrial Processing	unknown	
Total	2.5 nanotorr	

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material required from Earth—1 ton of material per person per month; however, since the lander is fueled from lunar-produced oxygen, the fuel for the lander must be delivered into lunar orbit. Total gas contribution to the lunar atmosphere is 720 tons/month, for a pressure contribution of 0.6 nanotorr. Habitat leakage and airlock losses will contribute 0.05 nanotorr.

Lunar oxygen production to fuel the lander will require 400 tons of oxygen per month. A 25% loss, my guess for what might be a realistic leak rate for a low-cost industrial process, would contribute 0.13 nanotorr. If the translunar injection ship is also to be fueled, this is an additional contribution. It has been proposed that lunar oxygen production could be used as a cheap source of fuel for spacecraft from Earth orbit. I assume a baseline facility designed to deliver oxygen to Earth orbit at a production rate of 500 tons per month. Lifting this from the Moon will require 400 tons of fuel, and leakage losses will be about 200 tons. The contribution to the lunar atmosphere is 0.78 nanotorr. This will be considerably less, however, if the oxygen is to be shipped by mass-driver rather than lifted off the surface by rocket.

The Moon's soil does contain trapped gas, primarily hydrogen and helium from the solar wind, plus some carbon compounds and nitrogen. The concentration is low, something like 50 parts per million, but it is only loosely bound to the soil. Physical disturbance, as well as movement of soil by mining, *etc.*, will likely release some of the gas content. This contribution is expected to be negligible compared to other sources.

However, we may want to *use* this gas. Fifty parts per million isn't much, but it seems to be the best source of hydrogen on the Moon, and it's conveniently easy to recover—literally, all you have to do is shake and bake. Possibly more importantly, the helium in the soil contains a trace amount of the rare isotope helium three (^{3}He). Helium three would make a very nice fuel for a fusion reactor—except that there is very very little ^{3}He on Earth. Mining the lunar regolith for helium three to fuel terrestrial deuterium-helium three fusion reactors has recently gotten many people quite excited[5] (of course, we *do* first want to learn how to make fusion work . . .). ^{3}He implanted into the lunar regolith by the solar wind would be extracted by baking the soil, distilled, and shipped to Earth for fusion fuel. And, for every ton of ^{3}He produced, about 3,300 tons of ordinary helium 46,100 tons of hydrogen, 3,000 tons of carbon monoxide and carbon dioxide, and 500 tons of nitrogen will be produced. Ten tons of ^{3}He mined per year would fuel half the US electrical consumption, and most of the byproduct gasses produced will be useful to the lunar base. Except for refrigeration and pressurization use, however, the helium produced will not be of great use, and will likely leak to the atmosphere sooner or later. Fortunately, the escape of hydrogen and helium is so fast that despite an estimated 50,000 tons of hydrogen and helium waste released to the atmosphere, the pressure contributed is

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trivial.

If 25% of the gas content lost as waste due to soil agitation during mining plus leakage, and in the baking and condensation process, our 10 tons per year of ^{3}He will produce 12,000 tons/yr of carbon dioxide and nitrogen, which results in a contribution of 0.87 nanotorr.

The moonbase is also likely to be a place where many other mining, refining and manufacturing operations take place, producing solar cells, aluminum and titanium structures, habitation modules, and many other objects useful to further industrialization and colonization. These processes will certainly result in some amount of gas generation and, consequently, wastage. But until the processes are more completely specified, the contributions from this processing will remain unknown.

The total contribution to the lunar atmosphere from the assumed industrial facility producing both oxygen and helium three is 2.5 nanotorr (see Table 1), a factor of 5-100 higher than the "natural" daytime atmosphere. This is low enough that manufacture of amorphous silicon solar cells can be performed without any additional vacuum pumping. For other processes I mentioned earlier, such as MBE, traveling-wave vacuum tube formation, or siting of a supercollider on the Moon, the vacuum is *not* good enough, and these will require additional pumping.

4. Luna City

What about the future? What happens when Luna City becomes a major node of solar-system transportation, with a population of a million industrial workers?

We can expect that as the technology gets better, the sources of gas leakage will decrease. Mass-driver based systems will undoubtedly be used for outward-bound transportation, except for human beings, and it is likely that some sort of tether system might be used for transport as well, of humans as well as cargo, eliminating rocket exhaust pollution almost completely. On the other hand, this will be offset to some extent by the fact that as living on the Moon becomes more routine and transportation costs drop, people will begin to pay less attention to small losses, and as new mining and manufacturing capabilities come on-line, new sources of pollution will appear as well. So it's hard to predict too far in the future. As a rough estimate, perhaps we could guess that each person in Luna City will produce a quarter as much waste gas as produced per person by the 250 person industrial base. This results in our million-person Luna City having a pressure of two and a half microtorr, making for a very dirty vacuum indeed.

While the lunar vacuum may not be sufficient for some operations, it must be kept in mind that even after degradation, the ambient remains a very high vacuum. It is much easier to pump a starting ambient of one nanotorr down to ultra-high vacuum than it is to reach it from atmospheric pressure. Leaks will be little problem; there will be almost no problem with desorption of gasses from chamber walls that have been exposed to ambient, and finally, the "vac-

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uum chambers'' will not be required to hold up to the large mechanical pressure of 10,000 tons/m^2 imposed by the Earth's atmosphere.

It is an advantageous feature of the Moon that the vacuum is self-cleansing by the solar ultraviolet and solar wind. ''Air pollution'' is a temporary effect. If it is decided that a high vacuum is required, a wait of a few hundred days will suffice for the gas to be removed by the solar wind. However, this is only true as long as the amount of atmosphere present is low enough that there is little shielding of the solar UV. This is likely to be true for the amounts of gas discussed so far. Some amount of gas will be adsorbed by the lunar soil. Cleansing of this gas to restore the original ultra-high vacuum will take longer, since the soil will take time to outgas.

5. Atmosphere Variation with Position

So far I've assumed that the waste gas is evenly distributed around the Moon.

The immediate vicinity of intermittent gas sources, such as the exhaust plume of a lander or the area adjacent to an airlock during depressurization, will have large, but temporary, surges in the gas concentration. Such surges in pressure were seen, for example, in results from lunar atmosphere experiments on Apollo missions where the observed pressure rose dramatically when the LM was depressurized, when an astronaut approached the apparatus[6] (due to exhaust gas from the astronaut's EVA suit), and on lift-off of the LM from the surface. These pressure surges were superimposed on a longer term transient due to gradual degassing of the LM. Sensitive processes would likely be shut down during such periods.

Gas molecules escape the lunar atmosphere primarily from the sunlit hemisphere of the Moon, where they have higher kinetic energy and also are subject to photoionization by solar UV. Thus, the escape lifetime is determined by the gas distribution on the sunlit hemisphere.

For pressures of nanotorr and below, the distance traveled by a typical molecule between collisions with another molecule is hundreds to thousands of kilometers; thus, the movement of gas in the atmosphere is primarily via ballistic transport. Gas molecules leave the surface with random direction and a thermal velocity profile, follow a ballistic trajectory until again intersecting the surface, and then may be temporarily adsorbed by the surface before bounding off again at a random direction and velocity. Adsorption of gas by the surface is irrelevant to final pressure, since the adsorbed gas neither contributes to the total pressure nor is subject to escape; although a large amount of gas stored in the adsorption reservoir does increase the time needed to reach equilibrium pressure as well as the time needed to purge the atmosphere after the gas source is discontinued.

At the daytime surface temperature of 365° K, the average horizontal and radial velocities are 300 and 430 m/sec respectively for a typical molecule (here assumed to be O_2). The distance this typical molecule travels on an average

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"hop" is 160 km, spending 380 seconds in flight before bouncing off the surface.

In a random walk process the average distance traveled equals the distance *d* per step times the square root of the number of steps (just take my word for it, OK?), so to cover the surface area of the Moon thus requires 450 steps, and a total flight time of 47 hours. This time is short enough compared to the escape lifetime of gas in the atmosphere that the assumption of roughly uniform gas distribution is justified, and there is little difference in the amount of gas near and far from the base.

Hydrogen and helium, though, being considerably lighter, spread across the full surface area of the Moon much much faster—in fact, in just about an hour. Since the escape time for hydrogen and helium is much *less* than an hour, gas concentrations for hydrogen and helium are *not* uniform, and considerable variations in density will exist between areas close to the gas source to areas far away.

On the night side of the Moon, where the temperature is considerably cooler, molecules take six times as long to diffuse across the same area. Since any given molecule will spend six times as long on the night hemisphere as on the day hemisphere, the gas reservior on the night side will be proportionately greater.

6. Conclusions and Speculations

Establishment of a large lunar base will indeed pollute the lunar vacuum. The time scale for distribution of exhaust gas across the surface of the Moon is much less than the escape lifetime of the gas in the lunar atmosphere, and thus exhaust gas ends up uniformly spread across the surface. A 20 person exploration base will contribute negligible pollution, but a 250 person "industrial" facility could degrade the lunar ambient to levels on the order of 3 nanotorr, replacing the mostly non-reactive gasses hydrogen, helium, and neon with more reactive gasses containing carbon and oxygen.* This vacuum is still good enough to perform some vacuum processes, such as making amorphous silicon solar cells, but other processes will now require pumping down to a *good* vacuum. Establishment of "Luna City" would inevitably degrade the lunar vacuum much more.

As a concluding speculation, so far I've been assuming that an atmosphere on the Moon is bad. But, if we think far enough into the future, wouldn't an atmosphere on the Moon be *good?* Can we put so much gas into the atmosphere of the Moon that it could become breathable, to turn the formerly lifeless Moon into our nearest habitable world in space?

As R.R. Vondrack[1] pointed out, if you put enough gas into the atmosphere it shields itself from the solar UV, and so the heavier gases, like oxygen and nitrogen last thousands of years, instead of months.

*Some people might want to quibble about my characterizing hydrogen as a "mostly non-reactive" gas, since here on Earth it's manifestly very reactive (with air, anyway). Since my main interest is semiconductor manufacturing, where hydrogen contamination is harmless or even beneficial, that's partly my personal bias. However, on the Moon, with no free oxygen and a scarcity of oxidizing agents of any sort, there isn't much around for hydrogen to react with.

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That's a lot of atmosphere needed. About the minimum you could expect a human to be able to breathe is one PSI of pure oxygen, which is about 50 torr—twenty *million* times the "pollution" level of "Luna City."

Could we manufacture the oxygen? We would need something like two hundred trillion tons. The chemical composition of lunar rock is about half oxygen; all we have to do is reduce the oxygen out of an amount of rock equivalent to a cube about fifty kilometers on an edge. That's a lot of rock. On the other hand, it's a small volume compared to the size of the Moon. Such a chunk of rock reduced to oxygen would give the Moon an atmosphere that would last three thousand years—longer than any civilization on Earth has ever lasted, and when it leaks away, we could keep replacing it every few thousand years for a long, long time before we even begin to use up the Moon.

But the amount of energy needed to turn half a quadrillion tons of rock into oxygen is mind-numbing! Even fusion energy wouldn't be enough—we'd pretty much require some way of making direct conversion of matter to energy. And if we can do *that*, minor projects like terraforming the Moon become trivial.

Alternatively, if we could find an ice cube fifty kilometers on an edge and crash it into the Moon, the Moon would acquire an atmosphere of water vapor. That, as it happens, is just fine—in a relatively short time (well, "short" might mean as much as hundreds of years) ultraviolet from the Sun will split off the hydrogen, which leaks away, leaving atomic oxygen, which will quickly combine to form ordinary O_2—just what we need to breathe.

A comet pretty much fits the description of a floating ice cube (or at least a snowball). Unfortunately, 50 kilometers across is quite a large comet. Comet Halley, for example, the only one we've ever gotten a good close look at, has a nucleus only 16 kilometers across—it would take fifty to a hundred comets this size to do the job, even assuming that the water doesn't splash away when the comets hit the Moon!

But there are plenty of comets out in the Oort cloud. And some of them might very well be *big* compared to Halley. For example, consider the object called Chiron that circles around somewhere outside the orbit of Saturn. Chiron was once thought to be a large asteroid but is now known to be a comet, or at least a comet-like object (it has a cometary halo). And Chiron is almost two *hundred* kilometers across. Plenty of ice to split off a chunk to give the Moon an atmosphere, and save lots for later.

Leaving plenty of problems to be solved for later. Like, just how do you propel a comet, anyway? Would anybody sane ever let you do it? (Keep in mind that if you should miscalculate and hit the Earth by mistake, you'd make "nuclear winter" look like a warm spring afternoon.) What do you do with the inhabitants of Luna City when the comet hits? And just how do you expect to renew the atmosphere after a few thousand years, when there is a thriving civilization on the Moon that would just as soon not get hit by a comet?

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All these are problems for the next millennium. For now, it would be a start just to get the moonbase up and running. But it doesn't hurt to dream. . . .

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●Definition of Utopia: No borders and no neighbors.

Abba Eban
Submitted by Ira Stoller

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Jay Kay Klein's biolog

You'd expect someone who had two cats named "Quark" and "Lepton" to be exactly like Geoffrey A. Landis. Advanced education started at MIT, where he received BS degrees first in physics and then electrical engineering. Brown University in Providence provided a Ph.D. for work on experimental solid state physics. His specialty was trying to increase the efficiency of single-crystal silicon solar cells.

Having briefly spent time in about as many states as the average electron, Geoff has transited from Detroit to his current location near Cleveland, where he works at the NASA Lewis Research Center. Geoff organized the "Vision-21" conference that focused on speculative thinking about hardware beyond the next generation. Keynote speakers included Robert Forward and Marvin Minsky. His work on improving solar cells has resulted in over 50 technical papers and a couple of patents. He is thus a sort of "ideal" high-tech *Analog* author: a part-time writer who does high physics in his mind, and engineering with his hands.

As a National Research Council fellow, he can work on projects that catch his interest. This often results in visiting interesting places. Last year, he presented a paper on solar cells in Madrid to the European Space Power Conference, and *then a pair of papers in* Malaga to the International Astronautics Federation. One was on photovoltaic power for a moonbase and the other on laser-propelled lightsails for interstellar flight.

His pet hobby, after writing SF, is model rocketry, even to the extent of being an official in the National Association of Rocketry. In 1978 he was a member of the US team that went to Jambol, Bulgaria for the Spacemodelling World Championships. He was also on the MIT human-powered *Chrysalis* flight team, and on the *Monarch* team that won the Kremer speed prize.

His first story in *Analog* was the lead-off novelette for December, 1984, followed by a short story in June, 1985. Both were awash with super-high tech, but both also had something from a dimension beyond space-time. Somehow, many *Analog writers go beyond physical facts* to pure imagination and wild-card plots. This was probably what led this magazine's legendary editor, John W. Campbell, to start a companion "Engineering oriented" fantasy magazine, *Unknown Worlds*.

Unable to approach anything except in an all out fashion, Geoff attended the 1985 Clarion SF Workshop. Geoff's prescription for SF is probably one that produces the best stories: write the type of story you like to read yourself and don't try to churn out something you think is currently in fashion. *Analog's* uniquely qualified set of readers appreciate stories that are on the borderline between the known and the unknown in a fusion of engineering and cutting-edge physics. ■

Geoffrey A. Landis

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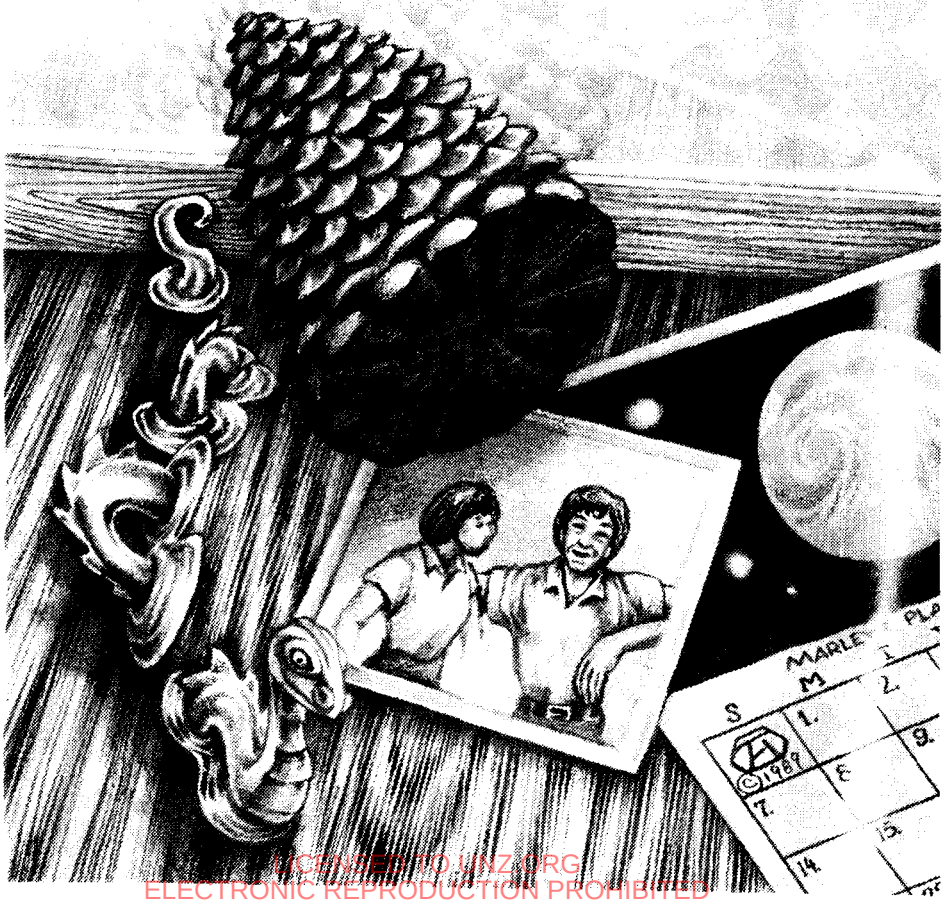
LOOK CLOSER

Amy Bechtel

One of the things that draw people
outward is the lure of the exotic.
But there's a funny thing about that . . . .

Todd Cameron Hamilton



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Jess was taking the star maps off her wall when she heard a commotion outside in the yard: shouts, the rev of a motorbike, the sudden clatter of many small hooves. She rolled the maps carefully and went to look out the attic window. Her dad and her brother Hamish were bringing in the last mob of sheep off the hill pasture; it was shearing time. For a moment Jess felt out of place. She ought to be down with them, helping with the work. Shearing had hardly begun, and next year when tupping season and lambing season came round, she would be gone. She was eighteen and she was leaving the small sheep farm where she had lived her life; she was leaving it forever. This very day she would catch a bus to Invercargill, and from there fly south, to Antarctica, to her future.

Jess turned away from the window and went back to her wall. Underneath the photographs of Marley's Planet she found a half-forgotten snapshot her mother had taken, long ago: Jess and Hamish (as small children) standing in front of Lake Pukaki. In the picture, the child Jess clutched an enormous pine cone, and instead of smiling at the camera like her brother, she stood with her head half turned away, gazing out at the lake.

The first time Jess saw Lake Pukaki, she thought she must be on another planet. The lake was turquoise, so brilliant, so vivid, it did not seem possible that it was merely water. The bushes around the shoreline, spiked with thorns, looked alien and mysterious. Jess ran down to the lake shore to touch the weird water, to cup it in her hand, and she peered into the depths, hoping to see some strange and wonderful creature. But all she found was a pine cone, a huge heavy cone that lay less than ten feet from the brink, but looked as if it had never touched the water. Jess picked up the pine cone and held it close. There were no trees anywhere in sight.

She was six years old then, on holiday with her family, in a place even more remote than the South Island sheep farm where she had lived all her life. The turquoise water fascinated her even after she realized there was no mysterious intelligence lurking within. But her mother explained the color, speaking of types of soils and rocks and the mineral content of the water, and when Jess went back the next year, the lake had lost its magic.

But she kept the pine cone. For years it rested on a shelf under the window of her attic bedroom, the one constant decoration in a shifting, changing room. As she grew older, the animal figurines and wall posters (baskets of kittens, wild foxes in a forest, young girls riding long-maned ponies through meadows of flowers) gave way to solar-system mobiles, and star maps, and a photograph, cut from a calendar, of Loch Ness.

The pine cone stayed in the same spot, on the same shelf, until Jess was thirteen. That year one of the old sheepdogs had a pair of pups and died during the birth, and Jess was given the orphans to raise. At first she had to catch one of the goats in the yard and milk it, and then bottle-feed the pups. But soon the pups were big enough to nurse straight from the goat, and she had only to catch and hold it for them. One day she went

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out to fetch the goat and found that it was already caught. One pup was holding the goat by the ear while the other had its fill of milk. As Jess watched, the two pups switched places.

Jess' dad kept one of the pups, named him Mick, and began to train him. Mick was full of mischief from the beginning. He could always find a way into the house, no matter how it might be barricaded against him, and he liked Jess' room best. He would run to the window, grab the pine cone, and chew on it happily till Jess took it away. By the time Mick was done teething, the pine cone was looking ragged and a large chunk was missing from one side, but Jess put it back on the shelf beneath the window, and touched it now and then.

When Jess was fifteen, her dad went overseas to Scotland, to attend a sheep management seminar. Jess begged to go along. Her dad finally gave in, and once they were in Scotland, she made sure he took her to Loch Ness. They arrived at the loch on a foggy evening, just at dusk. The water rippled, fish jumped, and Jess held her skirt in her hands and waded knee-deep into the water. Monster, she thought. Intelligent, elusive monster: please let me see you. She stood in the water until her legs went numb and the stars came out and the mists rose off the water. But no monster came. There was no mystery here, no life, no mind. Only a big loch, full of fish.

Jess returned home, took down the calendar picture of Loch Ness, and pinned up a group of photographs of Marley's Planet. The first planetfall had come while she was in Scotland, and the pictures sent back showed a beautiful place, green and misty, with tall spindly mountains like spires, and thin delicate trees so tall their tops vanished in the clouds. And Marley's Planet bore traces of life. Possibly intelligent life.

"Hey! You little beggar, get back in there!"

Jess pulled the last photograph off the wall, laid it on her bed, and grinned: it was Hamish, his voice loud enough to carry all the way up from the yard. She ran to the window; she could not resist the fun of watching a sheep get the better of Hamish.

She peered down. The last sheep in the mob had had second thoughts about entering the woolshed; it darted back out past the gate and tried to slip past Hamish, very nearly succeeding. Then Mick arrived, his ears pricked with delight. He crouched low in front of the errant sheep, and a strange, glazed look entered his eyes. He crept forward, holding the stare, and the bewildered sheep slowly backed through the gate, up the ramp, and into the woolshed. Mick was an eye dog; he could hypnotize a sheep with his stare. And he dearly loved to do so.

Hamish shut the gate on the difficult sheep, closing it in the woolshed, but Mick slipped through the gate and continued to creep forward, forcing the sheep farther and farther into the shed.

"Mick, that'll do," Hamish said. Mick feigned deafness, even though Hamish's voice was still loud enough to carry all the way to Jess' window. Mick was having fun. He didn't want to stop.

"*Mick!*"

Reluctantly Mick cocked one ear

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back, listening; Hamish said, "Get in behind," and the dog slithered through the fence and came to heel, panting up at Hamish. He wanted more work to do, but the work was done.

"Fool sheep," Hamish said.

His dad said, "Smartest one in that bunch, *I'd* say."

Jess smiled, and watched as the two men left the woolshed and crossed the yard to the house. They disappeared inside, beneath her feet, and Jess looked back at Mick. The dog was sitting in the yard, staring straight at her, his head tilted questioningly, his ears flattened. When he saw her looking, he began to whine.

"Jess! We leave in ten minutes," her mother called from downstairs, and Jess, after an instant's hesitation, broke the dog's stare, and hurried to pack the photographs and star maps. Finally, carefully, she packed her pine cone. Everything else was ready. She fastened her suitcase, picked it up, and hurried downstairs. Mick was on the landing when she came down. She stepped over him, and he followed her down to the kitchen, his eyes on the suitcase.

"How ever did Mick get in the house this time?" her mother said.

Hamish grinned. "I saw him. He opened the latch on the back door, and shut the door behind him. Remember the time he came in through the skylight?"

"How I do. I suppose we should be grateful the chooks and the sheep don't follow him in."

"Is it time?" Jess said, impatient.

Her dad glanced at his watch. "It is," he said. "Well. Shall we load up?"

Leaving was much easier than Jess had imagined. Her parents were uneasy, their words brief and awkward, but they said no more to try to convince her to stay. All the arguments had been gone through already. Leaving, Jess thought; she was leaving the farm forever. Even if she failed in her quest, she did not intend to come back. She peered out the rear window for one last look. The roadside pastures were empty, the sheep all waiting in the woolshed, but birds flitted through the windbreak pines, singing, and Mick stood by the gate at the very edge of the property, watching the car, one ear up and one ear down in his most perplexed expression. His gaze locked with Jess'; she was caught and held by his eyes, but then the car rounded a corner and Mick vanished from sight.

Jess drew a window seat on the plane, and was one of the very first on board. She peered intently out the window as the plane took off, banked, and headed south over the ocean.

"Ever been down there?" someone said. Jess looked up. Her seat-mate, an intense-looking redheaded young man, was looking at her inquiringly.

"Down where?" she asked.

He leaned past her and pointed out the window. "There. See? That's the very southernmost tip of New Zealand. You can stand and look out on the ocean, and sometimes you can almost see Antarctica."

"I've never been there," she said. "I'm from inland country. Near Wanaka."

"Raise sheep, do you?"

"Yes. All my life."

"It's amazing how the market for real wool keeps getting bigger and bigger,

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isn't it? Living on a sheep farm must have been fun. Marvelously old fashioned."

"It's over now," she said. "I'm off to University."

"Are you? So am I. What are you going to study?"

"I'll be with SETI," she said. "Outbound branch."

His eyes widened. "Imagine that! It's hard to get into, that is. I heard there were twenty times more applicants than there were places. You'll be off to Marley's Planet, then?"

"I hope. So long as I pass the training program."

"I envy you a bit. I thought about applying, myself, but never did."

"Why not?"

"I was afraid they might accept me! And I kept thinking of all I'd have to leave behind." Jess looked out the window. There was only ocean beneath them now; the land was almost out of sight. The young man went on, "It'll be such a very long trip. I like having familiar things around me. My Grandma once drove me out on a little road west of Invercargill, and she showed me the place where she accepted her marriage proposal. She and Grandpa were in a buggy, and Grandpa stopped the horse and proposed, right in the shade of a big macrocarpa tree. Now they're both gone, but every time I see that tree I think of them, and remember something else about them." He paused, and smiled. "Besides, there's Moby and Dick. My goldfish."

"Your goldfish?" Jess said blankly.

"Well, I've not even learned to communicate with them, yet. One step at a time."

Jess laughed. "Communicate with a *goldfish?* But they're not—"

"Not sentient? Maybe not. But what have they found on Marley's Planet? They're not really sure yet, are they?"

"It's an intelligence," Jess said. "A mind at work."

"Maybe."

"I know it is."

He gave her a look, and she flushed, realizing how foolish her last statement had been. She said, "The beings on Marley's Planet could be anything! We'll never know until we study them properly. They might be as intelligent as us. Maybe even more so. They might live their lives and think their thoughts in ways that *we* can't even begin to understand."

The young man smiled gently. "Yes, that's so," he said. The plane banked and began to descend, and he looked out over the wing at the sun-touched blue of the ocean. Jess followed his gaze. Far below, out of her sight, a dolphin broke the waves, noted the presence of the plane, and dove again. In the hold the baggage shifted, and in Jess' suitcase another spine broke off the ravaged pine cone. Jess felt a chill, a vague discomfort with what she was doing, what she was leaving, but she would never turn back now. Back on the farm, Mick sat by the gate, staring at the road, his gaze fixed on the last spot he had seen her. As if he could draw her back; as if he could make her look closer, and see what had been around her all along. ■

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THE FLOWERS, THE BIRDS, THE LEAVES, THE BEES

L. A. Taylor

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"Oh! Aren't they darling!"

That was my tempengineer. The project must be slipping in prestige, I thought: this girl was fresh out of school, on her first off-earth assignment. Well, make allowances, I told myself. She'd throughported from the transport ship to her first job not three hours before—who wouldn't be excited? Now, with her nose practically stuck to the viewsim screen, she was observing one of the subjects of our study.

"It's purring!" she squealed. I looked for succor from above, in ageless human fashion, but saw only the sky blue padding of the labship's walls.

"Yeech! How do they see?"

She'd noticed the Kitten's eyes.

Given their velvety-looking hides, their size—a little smaller than the average house cat—and their purring protolanguage, I guess it was 99 percent sure that the first human beings to land here would call them "Kittens." The velvety "fur" is a deep, scintillating wine red, certainly a color no earthly kitten ever boasted. Their huge, rounded eyes are a changing blue, with a distressing blind look produced by the absence of any pupil. In dim light, when the eyes are almost navy, it isn't too bad, but this was midday, planet time; the Kitten's eyes were the clear pale blue of the tempengineer's own.

"We've never dissected one, of course," I told her, "but the general consensus is that light control is accomplished by several hundred thousand tiny, uh, shutters in the, um, what corresponds to an iris. They seem able to spread or contract some pigment in specialized cells, somewhat the same way a terrestrial chameleon changes skin color. We're not sure."

"Why not dissect one, then?" she asked, with a sideways glance at Paul to see how he was taking her.

"Against the rules—don't you know?" I was shocked. So was Paul: his mouth was actually hanging open. "They've got a rudimentary culture and at least as much intelligence as real cats."

Though some work had been done before—mainly tagging and tracking—we began an intensive study of the Kittens only two Earth-years ago. The "fur" is no fur, that we know. The body it covers is shaped more like a tailless lemur's than a cat's, but Kittens they are and shall remain. Like cats, they have retractile claws, but the Kittens have two to a digit, that arc out a surprising two centimeters, needle-sharp. Unlike cats, Kittens can control their claws individually. The digits are paired, two facing forward and two backward on both fore and hind limbs. Between digits and claws they are capable of as delicate manipulation as any man. I was aware of Paul's explaining this to the new engineer as I swung my chair and stared at the viewsim of their world. The Kitten, of the moment, completed its examination of our external camera and loped away, revealing the hazy landscape and leaving the tempengineer with a disappointed downturn to her mouth.

Her name was Gloria—the tempengineer, I mean—after some ancient feminist, as she'd informed us within five minutes of arriving. I suppose in reaction to the reputation those ladies have,

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she'd turned out to be one of the most aggressively femin*ine* women I'd ever met. She had the stuff for it, too, lean waist and long legs and firm mammary appendages, and that red-blonde hair in a cloud around her sweet face, as if she'd just walked off a pin-up poster and pulled on a jumpsuit. Her tour, thank Heaven, would be short: her job was simply to bring our old equipment up to standard. Already I didn't see how I was going to hold my research group together four more days, let alone Gloria's four whole months. I'd had one like her before; male, that one: a technical whiz shoved through school so fast he'd never had a chance to develop the social common sense of the average ten-year-old. Bad news.

"They look so cuddly," Gloria said wistfully, interrupting just before Paul's standard description of the Kittens' sexless sex. "Can I—could I—go out and pet one?"

"Pet one?" Paul's face went blank.

"Absolutely not," I snapped. "No one goes out on the surface. Where did you go to school, anyway?"

Gloria lifted her chin and named an excellent university.

"Then you ought to know better."

"But they're so cute," she pouted. "Nobody told me they'd be cute. And it doesn't *look* bad out there."

Above my head I saw only the padded shell of the ship.

"Look," Paul said, in a confidential tone of voice. He sneaked a look at me, but I stared at the viewsim, careful not to so much as glance at the rank of locker doors behind which hung the terrasuits. To go out. Out of the ship, away from the walls, to answer the siren call of fresh air and sunshine, just once. . . .

Because this is an Earth-like planet, as Paul was telling Gloria. Very slightly larger—one adapts to the greater gravity within a few days. The atmosphere is earthlike; roughly four parts nitrogen to one of oxygen, all the other gasses human beings evolved in and none we didn't. Plants cluster out there, green plants absorbing energy from a yellow sun in a blue sky, much like Earth. No particular spot on Earth; it's not that close. The ship sits in what might be a meadow, a tangle of grass-analogues and flower-analogues—*flowers*, damn it—purple and deep pink and orange and blue. . . .

Not too far away, a clump of trees squatted. Thicker-trunked than terrestrial trees, with odd, right-angled branches, as if some gardener had attempted to espalier them, forgetting that an espalier should try for two dimensions; they cast a cool-looking shade across the edge of the meadow. I heard Paul remind Gloria why we couldn't step into that exotic, tempting landscape—just that it *was* so much like Earth. The Kittens, like every other life form on every other Earth-like planet man had explored, base their inheritance on the same purines and pyrimidines as our own, locked in the same paired spiral. We have a kinship with the Kittens, but the relationship is potentially deadly. Who knew what viruses, what bacterium-analogues the Kittens might carry, less nuisance than a common cold to one of them, fatal to a man? Or vice versa? *Outside* was only in the terrasuits, only in emergencies. The unlucky person who made the trip would come

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back to days of decontamination. The epidemic spawned by the first incautious trip onto the surface of a strange world had seen to that. Still, the flowers were pretty. . . .

Elodie, Paul's wife, opened the bulkhead hatch cover and poked her head into the viewroom, keeping her balance with one hand on the handhold beside the hatch. "Lunch, anybody?" she asked. She was still smiling at Gloria, then.

We moved into the workroom—our lounge, dining hall, laboratory and library. Like the viewroom, what had become the ceiling once the ship landed was sky-blue; the deck a grassy green; factors supposed to keep us happily indoors when we could see so much of outdoors on the viewsims. Elodie had concocted some kind of a soup and a spread for the expandobread. She'd done her trick with the coffee to make it taste almost real. "Oh, that smells good," I said.

Gloria sat at the place Elodie tacitly assigned to her. "I wish I were good in the kitchen," she said. "Sometimes."

Elodie smiled, a strange, strained smile. "If you've spent as much time in a lab as I have, it's easy," she remarked. A quiet way of pointing out that the ship doesn't have a kitchen, or whatever you want to call it. Galley, I'd have said, but I'm the Navy man. The soup was delicious; the spread for the expandobread tasted like fresh chicken salad.

"But then, you *look* like you'd be good in a kitchen," Gloria continued. Her glance slipped sideways toward Paul once more. "It's lucky for us you're here."

Elodie sat with her head cocked, staring at Gloria for a good three seconds, before she picked up her soup spoon. She does look as if she'd be good in a kitchen: the kind of woman I call ample. Not fat. She just doesn't have the tight-knit leanness of a Gloria. Her face is soft and smiles easily, her forehead marked with what she calls "thinking lines," and her hair is skinned back out of her way. Paul's the xenobiologist, a lanky man with a lazy way of moving and a mind that races off in ten directions at once. Elodie, our psychologist and medic, has a special flair for xenopsychology, but she's scarcely out of touch with human minds. Part of her function is—was—to keep us all sane. They'd been with me two years the day Gloria arrived, since the Kitten study started.

"I'm sure you could learn to cook," Elodie said.

"Oh, my mother's tried and tried—mm, this is good!" Gloria smiled sweetly. "My mom couldn't do better."

Sure. Still nothing over my head but the pale blue padding of the ship. My ship, technically. That is, my papers say I'm the expedition commander, and I'm the one who would fly the lab if for some unimaginable reason it ever took off again. Mostly I just mooch around, doing long data runs and waiting for the others to get out of my way so I can continue a remote-controlled long-term geological survey. Twenty Earth-years long, so far, seven of them mine.

Gradually over the next few weeks

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the crew settled down, as much as people can in a hermetically sealed environment. The doubts I'd had about Gloria seemed groundless. She was as good an engineer as they come, almost telepathic when it came to adapting new equipment to specifications the rest of us could be all too sketchy about. If she had any designs on Paul or me, she didn't pursue them—at least, not with me around.

One day, about six weeks into her tour, I found her in the viewroom. "I've got this viewprobe working better, now," she said. She hunched forward in one of the command chairs, eyes on one of the smaller screens. "See what you think."

The probe was in the Kittens's nursery, a grove of the plant-like growths in which their young develop. "Gloria—" I began. Paul had done only the sketchiest work on the nursery. He wouldn't want it disturbed.

"I know, I know. Don't worry. They don't even know it's there. See?" Gloria leaned sideways so I could see the screen and squeezed the sound control. A contented purr filled the viewroom. "Look, there's one going to pop. Here comes the nanny."

On the screen, much clearer than before Gloria started tinkering, a rounded object glistened and trembled. With a faint *pff*, the object split down the side. A baby Kitten tumbled out. The nanny—more of our slang, but self-explanatory—loped over and gathered it up with her forelimbs, purring loudly. The baby's eyes lightened, adjusting to the sun, and the purr became a croon.

"Sweet, isn't it?" Gloria said. "You'd think they'd just leave the kids to bumble off on their own, wouldn't you? I've been reading up on alternation of generations, and that's what usually happens—the parents go on about their business, and by the time the second form produces the first form again, they've forgotten all about it."

"I'm sure ferns have," I said.

"Oh, you. But I mean, they're so maternal. . . ." She caught her lip under her teeth. "It's too bad they don't live longer."

"Eight years? That's not bad, for such a small animal."

"Parrots aren't any bigger, and they live twelve times as long."

"Where'd you learn that?"

"The ship has a standard rec and info library, thank God!" She sighed. "I'd go batty without it. You've got next to nothing for me to do, and nobody has any time to talk over your research with me. I like to exercise my head once in a while."

On the screen, the nanny gently rolled the new Kitten onto its feet. It stumbled along for three or four steps. "Oh, cute," Gloria breathed. "Isn't it cute?"

"Yeah, sure." I watched the nanny straighten the kid out. "That's good resolution you've got," I said. "How'd you do that?"

"Oh, I just put more pic cells in the screen." Gloria pushed me away from the screen to look closer. "I wonder when they'll take this one for its ceremony at that altar stone?"

"The Kitten? How should I know?"

"I mean, I wonder how they decide when to take them."

Sometime in the next few days, the other adults would come for the new Kitten. Mewling and yipping, it would

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be dragged away and placed on the altar stone, a few words would be purred, and the baby would be returned to the nannies, who never seemed to leave the nursery. The timing of the ceremony varied from Kitten to Kitten. How did they decide? I wondered. "Got me. Ask Elodie."

"Elodie," Gloria snorted. "Elodie remains to be convinced that I have any capacity for understanding of exotic species whatsoever. Including *Homo sapiens*." With a wicked little smirk, she added, "Much she knows." Nanny and infant wandered away. Gloria got up and stretched, one long, lovely, stirring curved line. "See you later." She grabbed a handhold and swung through the bulkhead hatch.

I sat back, watching the screen. The Kittens, nanny and baby, were almost out of sight. Gloria had rebuilt the viewprobe controls a few days before, so the probe could be repositioned literally with a flick of the wrist. I flicked my wrist. Baby and nanny came back into sight, the nanny purring and chirping, the baby with an intense look of concentration as it fumbled into the rhythm of walking. *An intense look of concentration*, I mused. Why did I think that? I zoomed the viewprobe around to examine the baby's face, and couldn't spot the signs that had led to my diagnosis. "Projecting," Elodie would call it: judging the Kitten's emotions by what my own might be. I didn't think so.

Paul slammed through the hatch. "Hey, a breakout, and nobody told me! What the hell! How am I supposed to do my work without any cooperation?"

"Sorry," I said. "I didn't notice anything different, if that helps."

"If you were a biologist, it might. Normal kid?"

"Looks OK to me. One head, four limbs. Walks."

Paul grabbed the control and backtracked to the greenish growth from which the baby Kitten had burst. "Listen to that!"

The growth hissed, slowly deflating. Paul zoomed in for a closer look. The branch with the capsule in which the baby had developed seemed shriveled and dull. A moment later a nanny patrolling the row of brood-plants neatly clipped the branch with its claws and bore it away. Paul followed with the viewprobe. The Kitten tossed the branch on a pile of other rotting branches and ambled off. "Compost heap," Paul said. "They dig the stuff back into the ground around the roots."

"For an animal?" I asked.

"Why not? It might feed from microbes in the dirt. Plenty of other animals do."

"But the brood-plants are stationary," I objected.

"So? The Kittens keep track of them; part of their culture. I bet you anything that when the funds come through for another study site, we'll find aboriginal Kittens wandering around planting their jellyblobs any old place and walking away without so much as a glance behind them." He zoomed back to the nanny and her charge. "Hey," he exclaimed. "This is damn good resolution! Gloria do that?"

Not long after, Elodie came to me with a viewrecord in her hand and a frown on her comfortable face. She didn't seem to know how to start what

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she wanted to say, so I took the cartridge and asked, "What's up?"

"Run that. The spot's already marked."

I slipped the cartridge into the reader and touched the screen to bring the picture Elodie wanted up. "It's the nursery. So?"

"Do you see any nannies you recognize?"

"Sure. The one with the nick in its ear. I'd know it anywhere."

"Zoom in and save that," Elodie said. I touched four fingers to the screen to mark the corners of the enlargement I wanted and pushed a button to save.

"Now run this."

She produced another cartridge. I exchanged that for the one in the reader, which she reclaimed with an odd, furtive motion.

The picture came up. "Nursery again."

"See anybody you know?"

"Sure. The nanny with the nick in its ear."

"Same as the other?"

I split-screened, fiddled with the knobs that turned the images until the nannies were lined up, then superimposed the pictures. They fit exactly. "Same one."

"OK, pull the record."

I did. "Look at the date."

"Yesterday."

"Look at the date on this one."

"It's—Elodie, you must have made a mistake."

She shook her head. "No mistake. That's from the early years of the expedition, before any of us got here. I pulled it out last night. See, I've been wondering whether our presence—people have been here over three Kitten generations, after all—whether we've changed their culture any. The reports used for planning our study all sound the same, and we haven't seen anything different, but I got to wondering . . . sometimes when you take a look for yourself, things look different. So I looked, and there was the same nanny." Elodie bit her lip and frowned. "None of the reports mention that nick, not even our own. It looks like the result of some accident, don't you think?"

"Unless it's some kind of badge."

"Wouldn't there be other badges? Other Kittens with nicks in different places, or on the other ear? I'd think so."

I shrugged. "You're the xenopsychologist."

"How likely is it that a nanny would have the same kind of accident to the same ear as one three generations back?"

"I don't know. Not very, I imagine."

"But without knowing what the accident was, there's no way to check, is there?"

"Sure there is."

Elodie sighed. "I know," she said dully. "Check all the viewrecords, see if the same nanny is there all along. Match the faces, calculate whether the skull structure's the same. But what a lot of work!"

"Have you told Paul?"

"I wanted somebody else to see it, first. Paul—" She sighed. "Paul's been a little short with me, lately."

"Anything I can do?"

"Not for another seventy-three days." She gave me a wry little smile. "Then Gloria goes home and you won't have to do anything."

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I tried to look into her face, but she turned away, so I looked back at the records in my hands.

Kittens have an odd way of reproducing. Like terrestrial cats, they go into heat, but that's as far as the comparison goes. The "fur" that covers those compact bodies actually seems to be fine extensions of the cells of their skin, some sort of gland, a tissue as live as your own skin—not dead, like fur. When a Kitten "goes into heat," a gelatinous secretion accumulates on the "fur" near the shoulders. It's quite visible, a translucent creamy green against that deep red fur. When we've managed to get a chemical probe into the area fast enough, we've found airborne molecules like terrestrial pheromones, prompting Paul to remark that a Kitten in heat would drive a moth into a frenzy. A Kitten in heat also drives other Kittens into a frenzy. All of them rush to find another one in heat and push the two together. The mating pair gathers their secretions off one another's backs using their extended claws as combs. The combined secretions are kneaded together—one of the Kittens chews them—and they harden, rather like epoxies. From the hardened lump grows the greenish, plant-like organism that buds and produces a new Kitten. So far, not especially bizarre. Lots of wilder things in the woods.

The odd thing about Kittens is that they have set aside a breeding class—the nannies. At least one partner to a mating must be a nanny for the union to be fertile. Sometimes two Kittens who are not nannies mate: to me, the act looks furtive. Certainly they don't spend as much time chewing the mixed secretions. The resulting lumps are immediately carried out of the camp and abandoned, almost as if the Kittens were ashamed of themselves. (Elodie has always insisted that last remark smacks of human hang-ups.) Still, the abandoned lumps don't grow. They just rot.

All of this had flashed through my head as I looked at the dates on the cartridges Elodie handed me. "You want me to show these to Paul, then?" I asked.

Elodie's thinking lines deepened. "Maybe just come with me while I show him." She glanced at the clock. "Now's as good a time as any, I guess." She sighed. "He's in the viewroom with Gloria."

Once alerted, Paul went through the viewrecords, from the early ones without audio to the crystal-sharp ones recorded since Gloria had rebuilt our probes. The same nanny, the nanny with the nick in her ear, appeared regularly. Looking closely, all of us saw others we could recognize. Paul checked the skull structure calculations, which only confirmed what we could already see. In the whole thirty-one years of the expedition, only two nannies had died and only two new ones had been added. "I thought you'd zapped them," Gloria said.

"We did—or people before us did—zap a few. That was before we realized how much of a culture they have. The ceremonies at the altar stone, the breeding class, the simple tools. Everything you've seen since you came. But you can't go shooting radiopellets, no matter how sterile you've made them, into sentient life forms."

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"And tracked? They must have tracked. Didn't somebody tell me Kittens only live eight years?" she persisted.

"That's right."

"So what does this tell you?"

"It means the breeders live at least three times as long as the others." Paul stared perplexedly at the table as the rest of us stuffed our faces with something Elodie had made taste like fresh clam chowder. "The only precedents I can think of are among social insects. But it's there, that I can't deny," he added, as if he heartily wished he could deny the whole business. "And I can't tell what makes a nanny. It's not as if they feed them differently or wall them up in a brood cell. I guess I've got to go over those records again. Damn, I wish I had some idea what to look for."

With Paul and Elodie pursuing the longevity study, the probes were free most of the time. I was able to get on with my own work, soil sampling. Like most scientists, given a glimmer of success they ran with it: the three of us barely talked for the next month or so. One day, feeling stale and worn, I slipped through the hatch into the viewroom for a glance at the wide outdoors. Gloria sprawled in one of the chairs, gazing pensively at the viewsim.

"Doesn't it make you just want to go out and lie in the sun?" She flicked a glance at me. "Don't tell me, it's bad for the skin."

"It is, but I know what you mean."

"And pick a few flowers and feel the breeze in your hair—oh!"

"Quit that, Gloria."

"It's windy today." She nodded at the screen, where the trees bobbed awkwardly. "I saw a branch break off, not long ago."

"Why didn't you call somebody?"

"Should I have?"

"Of course! Any time we can get a sample without intruding on the living ecology, we do. I'd better get a start on that and see if I can haul Paul away from those antique records."

"Has he discovered anything?" she asked, sounding wistful.

"Not that he's told me." I sat down next to Gloria and studied the viewsim. "Where's that branch?

She pointed it out. I dispatched a probe and called Paul on the intercom. "Sample it for me, OK?" he said. "I'm kind of busy. Just run the standard program; if there're any surprises, let me know."

"You know what I miss?" Gloria asked, as I keyed in the routine for the probe to follow. "Birds. This place doesn't have a single bird."

"Too high a grav for them, maybe." I watched the first reports on the branch come back.

Gloria sighed. "Still, I miss them. And butterflies, of all things."

"Oh, there are plenty of insect-analogues." I keyed the next part of the program into the probe.

"Yeah, but no butterflies."

"Well, no, most of them crawl." The branch held no surprises. Its similarity to earthly wood had been surprising, years ago, but no longer. "Lignins," I said.

"Is that their name? Those bumbly things like bees?"

"No, that's something I just found in the branch."

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Gloria stretched out her feet, still gazing at the viewsim. "Clouds," she said. "That's something. And the sky is blue. My sister went someplace where the sky was lemon yellow. She quit before her first tour was up."

Another day, a few days after the branch broke, I went into the viewroom for an early start on my own sampling and found Gloria there before me. She had turned a seat around to kneel in it, her arms folded on the padded back. Head on her arms, she gazed dreamily at the viewsim. I stopped mid-stride to stare. "I don't think I've ever seen the air that clear before, not in the whole seven years I've been here," I remarked.

"That's not the air." Gloria slid into the seat of the chair, facing me. "I didn't have anything better to do, so I upped the sharpness again. Nice, huh? Looks more like a window."

"It sure does." I walked up to the viewsim screen and spread my fingers on it, as if it were only a sheet of glass between me and the outdoors. "That's great! You can even see the mountains—they never differentiated on viewsim before."

"Sure they did, years ago. This ship is wearing out after all this time, that's all. I just replaced a few more circuits. The real trick is the controls." She grinned. "I'm pretty proud of them. All done with my patch kit."

The controls she'd redesigned *were* good, I realized. So suited to the human hand and reflexes you didn't even need to think to use them. "Gloria, you are a bona fide genius. How come they sent you on an assignment like this?"

She sighed. "You know what I'd be doing if I ever let on how much I know? I'd be ant number 763,000 in some big government project, with fifty bosses looking over my shoulder. Maybe if I got *real* lucky I'd be semi-responsible for designing one boring little gadget some technical describer would turn into gobbledegook so everybody could forget about it."

"You think this is better?"

"Yeah, sure. I'm only bored to death 90 percent of the time here, so it's got to be better as far as my brain goes." She was still looking at the screen, flicking a viewprobe from spot to spot in no particular pattern. It lit on the nursery. "Actually, sometimes I'd rather be as dumb as a nanny."

"As dumb as a nanny? Are they especially dumb?"

"Sure." She swiveled the chair to face me. "Haven't you noticed? They aren't nearly as bright as the others. I can practically translate every word they say—*Oh, good boy, that's the way, come on, now, great, that's it, you're doing fine . . .* No, no! *Bad Kitty!*" She let her lower lip slide out, the sullen teenager she might have been six years before. "They don't even talk to each other unless there's a baby around." A complaint. "And the babies only stay with them a few days before the others come and get them."

"You know, you're right," I said. "I wonder if Elodie's noticed that?"

"Sure she has, she's no dummy herself. I asked her about it. She thinks they're just bored." Gloria paused. The all-too-familiar petulant grimace crossed her face. "*I* think they got a whack on the head, and they've got nothing left

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but their instincts. Still, sometimes I'd even rather be like them."

"What on earth for?"

"That's it. That's it exactly. We're not on Earth. I've never spent so much time cooped up in one place in my whole life! I want *out*."

"Weren't you confined in training?"

"Sure I was." She swung the chair to face the viewsim. "Viewsim and everything. A whole month. But if those guys think that's any preparation, they're nuts. See, you knew there was an *out* out there, if you cracked you could pound on the door and somebody would come open it. Anyway you'd be out as soon as the training was over."

"You get used to it."

"Sure," she mocked. "Maybe you, with your half-size heart, but not me. I'd rather play Kitten." She got up and lounged beside one of the lockers that held the terrasuits, stroking its plastic latch. "If I meow at the door, will you let me out?"

"Not on your life."

"You're right, I know. Still, imagine being out—with your mind intact, of course." Her shoulders drooped. "You know what's worst? The no-smells. No smell of rain, no smell of something growing. . . . Nothing smells different here, except when Elodie's mixing a meal. And that, it's all done with mirrors, you know? It's all the same damn stuff, a little more water or a little less, a drip of this chemical and a drop of that to give it a flavor—when she still had time to bother. I wish she hadn't told me. Now even the bread tastes like pap."

"Two more months," I told her, smiling. "And your tour will be over. That ought to help."

"Oh, sure. I'm scratching the days into the wall beside my bunk."

I shrugged. Obviously, nothing I could say would get her out of the mood she'd worked herself into. Another expedition commander might have been more sensitive, might have taken steps to head off her discontent. But I wasn't. I didn't. Elodie was the psychologist, not me. I relied—OK, maybe too much—on her. To tell the truth, smart, good-looking women like Gloria scare me a little. I tend to shut them out.

Four or five days later I started a new sector of the survey. I rigged a probe to detect radiation and started it off toward the mountains on its first run. Before it got halfway there, a strong point source registered, mixed alpha and gamma, something I'd never come across before.

I stopped the probe. "Hold this for me, will you?" I said to Gloria, who reached out an uninterested hand for the control. "I want to get a viewprobe on that, see what it is." I waited, but Gloria's hand lay still in her lap. "Gloria! I said I wanted a fix! Wiggle the control, will you?"

She did: the source of the radiation seemed confined to an area not more than half a meter wide. The hair on the back of my neck began to rise.

"Sending the viewprobe now," I said. "OK, give me my control back." I waited, clicking my tongue with impatience, for the viewprobe to match coordinates and show me what my source of radiation looked like. "Anything coming up on the screen?"

"Yes." Gloria sounded puzzled. "It's

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what Elodie calls the altar stone. Where they take the baby Kittens?''

I looked over her shoulder in disbelief. The stone slab, a marvel of Kitten engineering, was centered on the screen. ''The radiation source must be under the stone,'' I said.

''What kind of dose do they give those poor babies when they hold them down on that rock?''

''Geez. Six rads a minute!''

''You're kidding.''

''No. This calls for a conference. Get Paul and Elodie.''

Gloria reached for the intercom.

It was plain luck, luck that seemed good at the time, that one of the Kittens died two days later. In the face of our new puzzle—why a seemingly intelligent race should expose its young to a crippling dose of radiation, early in their lives—Paul decided he was justified in breaking the rules to do our first bit of grave robbing.

''It's something they found, got to be,'' I said, of the radiation. ''No way the Kittens could be producing stuff like that without our noticing. They probably don't even know it's radioactive.''

''Maybe not,'' Paul said. He pulled at his lower lip with two fingers for a moment and gave more instructions to the probe that was analyzing tissue factors in the dead Kitten. ''But they do know it makes a change in their children. They must think it has some kind of advantage.''

I tried to think of an advantage desirable enough to weigh against a considerably shortened life span, and couldn't.

''Big tumor here,'' Paul said, looking at his screen. ''The cells have gone wild, see?''

''I can't say I'd never have expected it,'' Elodie replied dryly.

The disorderly cells abruptly disappeared, replaced by a macroview of the purple tissue strangling the Kitten's vital organs as Paul touched the controls. I felt a little sick. ''It would have to be some advantage, to make them accept that!'' I protested.

''I know what it is,'' Gloria said softly. Elodie cast her an annoyed glance, but jerked her chin as an invitation to speak.

''It makes them smarter.''

''Oh, Gloria, come on!'' Paul said. ''That's a lot of radiation! It shortens their life span by at least two-thirds—how could it make them smarter?''

''I don't know, but it does.''

''What I'd like to know is where they got it,'' I said.

Gloria examined her fingernails and glanced up at Elodie. ''It's a fuel dump. Somebody came by, didn't find any intelligent life, and tossed out some spent fuel.''

''How would you know?'' Elodie sounded nettled.

''Look at the energy patterns. That alpha's plutonium, and the rest of the stuff is decay products. Where would plutonium come from on a no-tech planet? Got to be a fuel dump.''

''She could be right,'' I said.

''And the Kittens found out that if they were exposed to it, they got smarter,'' Gloria concluded. ''Neat, hey? Some jerk too lazy to find a better place dumps a fuel can a couple hundred years back, and here we are fighting

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terminal boredom to study an intelligent race we created ourselves!''

''Gloria, that's just impossible,'' Paul said. ''Why would radiation enhance intelligence?''

''That's your department. I'm going to bed.'' Gloria got up, stretched, and headed aft.

Paul was just getting started. ''What other differences between the breeders and the non-breeders do we have?'' he asked himself aloud. His eyes narrowed. ''Just the fertility, but that's probably due to the radiation, too.''

I stirred in my chair as a half-formed idea struggled into my mind. ''Not quite true,'' I said. ''If one of the exposed ones mates with a breeder, they produce young.''

''The nannies never go near the altar stone,'' Elodie offered.

''That's it!'' Paul exclaimed. He hunched at the control board of his probes with a sharp inhalation. ''Wait till I get this comparison. . . .'' His fingers probed at the control board, tentatively at first, then with more assurance. The viewprobe showed the nannies' compost heap, a fresh branch withering on top.

''I'm going to bed, too,'' Elodie announced flatly.

''Umm.'' Paul's fingers moved over the controls of the probe that had produced the tissue assay of the Kitten. Elodie stared at him for a moment and turned on her heel and stalked out of the viewroom.

''Look! Look! It's starting to show!'' Paul exclaimed, a moment later. ''Oh, boy, is this exciting—look at that! That's not a different generation of Kitten! It's a totally different animal! Nothing like the tissues I just probed. We don't have alternation of generations, here, what we've got is alternation of species!''

''I never heard of it,'' I said.

''But that's what it is, look at those chemistries. When the Kittens mate, they must start this other animal growing, too. It carries along the Kittens's zygotes, see? Once it's adult, the Kitten forms. Probably without it the Kitten would just grow in that lump of glop—it'd be like an egg, see?''

He sat back from the controls for a moment, then pounced on them again. ''No, not that. It's a symbiosis. Because the sterile Kittens still produce the lump of glop. Maybe that's what makes them sterile, they don't have this other thing to grow the kids in.''

I waited, almost afraid to move, as Paul continued to think out loud. ''Yeah, that's what it is, the Kittens need this other thing to nourish the fetus, something like that, but for some reason they want to get rid of it for most of them, just save a small breeding stock—that's the only explanation, but I don't know of any other intelligent race that saves a stupid breeding stock—''

''There you go,'' I said. ''Normally, it grows in all of them and blunts their intelligence.''

''Some kind of brain parasite at that stage of its life? Yeah,'' Paul continued enthusiastically. ''And the Kittens can take more radiation than the other thing can, so they can kill it without killing themselves, at least, not right away. Then—what? Some kind of immunity, so they don't get reinfected?''

''Could it be—'' I started.

''Sure, they can only be infected be-

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fore they hatch! Got to be. But wait a minute. How did they find this out?"

"Spent fuel's in stainless steel cases," I said.

"Yeah, I like it." Paul grinned. "Some wandering herd of Kittens happens upon this pretty chunk of stuff, they stick around to admire it and suddenly some of the new babies are smarter than the rest of them. How many generations would it take for them to figure out that the cannister was the cause?"

I shrugged.

"We can order some old survey records when they come to pick up Gloria and see who might have left the fuel, when."

"If they were human."

Paul clutched the sides of his head. "Don't do that to me! I got enough to think about!"

I left him thinking and went to bed myself.

Where the dream came from, I'll never know. Out of some history record, I guess, snorting white horses dragging a red fire engine behind them, bells clanging. Someone in the crowd running after the engine grabbed me and started shaking. I came up through layers of sleep: Elodie was shaking me; the alarm bell clamored through the ship.

"It's Gloria," Elodie said. "She's gone out."

"Out! Where?"

"I don't know. Paul's trying to find her."

I dragged my pants on and hurried to the viewroom. Paul sat trying to watch four screens at once, all four viewprobes darting a search pattern. "Try the nursery," I said.

"Why would she go there?"

"I don't know, but she's spent a lot of time watching it."

Paul zeroed in on the nursery. The place was in an uproar, aimless nannies scurrying back and forth, ignoring a pod that had split and the damp, crying Kitten that had spilled from it. No Gloria.

"The altar," Elodie snapped.

"Use another probe."

Paul handed the controls of the probe in the nursery to Elodie and diverted another toward the Kittens's altar. More uproar: a band of Kittens crouched in defense around the slab of stone, their blue eyes almost black. In a moment a wobbly yellow light scanned the area; the Kittens' eyes lightened. Fur rippled as their muscles tensed.

"That's a flashlight," Elodie exclaimed. "It's Gloria!"

"What in hell is she doing?" Paul demanded.

Gloria strode into view, wearing a transparent terrasuit, an adult Kitten struggling in her hands. Creamy green gel dripped down her forearms; within the clear helmet the muscles of her jaw worked and her mouth opened in a tense square.

"She's in trouble." Elodie's voice held a peculiar mixture of anxiety and satisfaction. Gloria stumbled through the line of Kittens. She pressed the squirming Kitten against the altar.

"She'll kill herself," Paul groaned. "Oh, Gloria! That's hot!"

"The Kittens will get her first," I said, numb. Two sprang upon her with the eight claws of their front feet extended. They climbed her body to rake

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at her helmet and chest. The helmet bounced away. The suit tore. Blood spurted. My hands clutched the probe control. The audio came on. Gloria screamed. The sound rang through the tiny viewroom.

"I'm going to get her." Paul dropped the control he was holding and hit a locker release with the heel of his hand. The suit inside popped into his hands.

"You can't bring her in," I reminded him. "She's contaminated."

"Hell you say. I can get her into the lock, at least, and take care of her there. We can't just let them rip her to ribbons!" He already had his legs into the terrasuit; now he leaned right and left to shrug the shoulders over his own. "We'll worry about decontamination once she's safe."

"Paul, no!" Elodie pleaded. "What if they tear your suit? You could be—you could catch—"

"Can I leave somebody I've lived with for months to be ripped to shreds?" The zipshut reached his throat. He pulled on one glove.

"What about the rest of us?"

"We'll just have to take our chances." Paul brushed past her, headed for the bulkhead hatch. Elodie stepped back with a stunned nod. He settled the clear helmet over his head as he cleared the hatch. I hurled myself after him, but Elodie blocked my way.

"Let me out," I ordered.

"No!" Elodie locked her hands around the hatch handles. "Can't you see?"

"You've all gone crazy, that's what I see."

"Damn you!" Elodie's voice came through clenched teeth. "Don't you know they've been lovers, even with the longevity study? If he doesn't try to rescue her, he'll never be able to live with himself. And then he'll never be able to live with me. And I want him to live with me."

I grabbed her around the waist and yanked sideways, but she tightened her grip on the handholds and set her heels. "Can't you see?" she repeated. "I don't give a damn if she dies, but if she gets to be a martyr, Paul won't ever come back."

"If anything gets into the ship—"

"Then let him do it for the Kittens! Gloria doesn't know what you and Paul found out tonight. She was asleep when he came aft and he was so excited, he had to talk. So he talked to me! She doesn't know! She'll sterilize all their breeders if she's not stopped. The race, the intelligent race, will die out. All your fault!"

I stopped wrestling with her, not for love of Kittens, but because I'd heard the whoosh of the outer airlock door. Panting, still roughly embraced, Elodie and I turned to the screens.

Gloria in the nursery, doggedly pursuing a nanny. The suit was in ribbons. Thin strips of bloody flesh hung from her thighs and arms. The newborn Kitten still lay gasping on the ground. She snatched it up and cradled it in one hand as she crawled after the adult. The flashlight tucked under her arm picked out one unconnected detail after another, abandoning each in a trail of phosphors on the screen.

"You never told her about the Kittens' breeding arrangements," Elodie said, a monotone of accusation. "You never described their customs, just let her watch and watch and watch. How much could she learn in a couple of months, when we know so little after

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two years?''

''She's an engineer, not a biologist,'' I pointed out. ''Why give her that full a briefing?''

''She does have a brain.''

Paul appeared, shouting at Gloria through his clear helmet. I could see his mouth move and hear a vague suggestion of his voice, but not enough to understand what he was saying. He pried the infant Kitten from Gloria's hands. The thing was clearly dead, its head hanging sloppily. ''No-o-o-o,'' Gloria moaned. ''I have to clean her up.''

''You see?'' Elodie remarked, in the same emotionless tone. ''She's using gender terms when we know the Kittens have no sexes. She should have been briefed. It's your job to do that.''

''You could have briefed her yourself,'' I snapped. 'Poor kid was dying of boredom.''

''How was I to know?'' Elodie's mouth quirked in what looked like triumph. ''I was busy. With Paul.''

Paul shouted something at Gloria. She stopped struggling and looked at the animal lying across Paul's gloved hands. Green gel dripped: the Kitten's eyes were navy blue in the beam of Paul's flashlight.

''Dead.''

Paul's voice rumbled. ''It's better than spending the rest of her life bored stupid!'' Gloria flashed. She crumpled into a heap at his feet.

Paul flung the Kitten away and stooped to pick Gloria up. Elodie sighed.

My brain finally started working. I reached for a terrasuit.

A man can live a long time in a terrasuit. Rations and water are no problem, if you're sure the rations and water haven't been contaminated. Bodily functions can be taken care of; the suit's designed to do it. The air is filtered, the gloves easy to manage.

I'd barely finished the full connection procedure when the airlock bell sounded. Paul stumbled into the ship, carrying Gloria. Sometimes since I've wondered if he might have been exposed to the Kitten's parasite sometime before; it was such a stupid thing to do. Or was it just that she needed help, and he was a creature like the rest of us, needing sky and grass?

No matter. He and Elodie spent hours over Gloria, taping the long wounds, siphoning antibiotics and intensive rations into her veins to make the wounds heal faster. If I close my eyes, I can picture them, Elodie in the ordinary blue uniform we all wear every day, Paul still in the glassy terrasuit, helmet and gloves discarded.

Gloria went first. Thirteen days after her first attempt, fevered and dehydrated by radiation sickness, she escaped again and tried once more to expose all the nannies to the altar. The Kittens killed her.

Paul was second. He's an amiable guy, Paul, now that he doesn't get so excited over a project that he loses sleep and forgets to eat. Not that he's any more practical: until he left, I had to see that he remembered to add water to the rations, or he'd eat them dry and choke on the powder. I'd have kept him in if I could, but everyone has to sleep sometime. By the time the lock alarm woke me, he was gone.

He's happier outside, anyway, munching on the grass-analogues and the insect-analogues. The Kittens' parasite—or symbiote, if that's what it

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is—may even be the only organism on this planet that can infect human tissues. At least, Paul and Elodie seem perfectly healthy. They sleep under the trees at the far end of the meadow and forage among the grasses when the sun comes up. I've noticed that they've adapted to the longer day, now that the ship's lights no longer keep them to the twenty-four hour schedule we've always used.

Sometimes I think Elodie remembers. At least, she comes back to the ship occasionally and tries to open the lock. After awhile she beats on the side of the ship with a stone. When nothing responds she cries and lies down on the ground and kicks. In a minute or two she seems to forget what set off her tantrum and picks herself up and wanders off to find Paul. The Kittens don't pay either of them the slightest attention.

Paul was the biologist. Not me. I can't figure out how to know if I've decontaminated the labship: sure, I can follow the book, but what if none of the things I try works? And what about decontaminating me? The only method I can be certain about is the Kittens' altar stone.

I don't want to die with my hair coming out in clumps, spitting my teeth into my hands, sick and shivering. So, I've done what I can. I requested a comchannel from the monitor satellite. When it came through I sent up all the records that can go over microwave for storage there. The transport ship will find the message—and my warning—when they come back next month.

But some records can't be sent. The equipment, billions worth, is much too valuable to abandon. Then there's what Gloria did. Some engineer is sure to want to take a look at the stuff she built. Somebody will come. You. In the spacesuit I advised you to wear, I do hope.

I'm coding all of this—what shall I call it? —history into the central processor. I'll leave a nudge message displayed on the viewsim, where the first person who throughports is sure to find it. And then I'm going out. After all these years I'll finally sniff at this world's flowers and climb one of those squatty trees, find out if the shade of those leathery leaves is as cool as it looks. I'll tear the communicator out of the ship to take with me and send reports up the comchannel into storage for as long as I remember to. You've probably read whatever they turned out to be. Maybe you're a biologist. Maybe you, or one of your shipmates, can figure out some way to kill off the parasite; maybe even one that will bring us back—but you're too far away to help now.

As always, the viewsim shows sunshine. I'm going to soak up that sunshine and I'm going to turn on my heel and see a horizon uninterrupted by a bulkhead hatch, before I'm too stupid to appreciate it.

Because I can feel it coming on. Judging from Elodie and Paul, my mind won't last the week. Already, I'm not as sharp as I was when I started this story: something, spores, maybe, or a virus, got into the suit. I'll trash that when I go. The first guy into the ship can read all of this—no problem, even in a spacesuit, which I strongly advise you to trash, too.

And if you were too impatient to bother wearing one, friend, come on out. The weather's always fine. ■

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futures

Matthew J. Costello

I had to be dragged into the now-irresistible computer revolution. After four long undergraduate years in a high-pressure Engineering/Science school, I emerged with more than a mild phobia about technology. But as we all know, owning a computer is about all the persuasion you need. When I think of the drudgery involved in writing before word processing, it seems absolutely barbaric.

And, like a good many users, I jumped onto the clone bandwagon, purchasing what was reported to be an IBM-compatible machine.

But there are clones . . .and there are clones, and compatibility, my dear Watson, is very much relative. Nowhere is this more obvious than in the game world. Sierra On-Line (PO Box 485, Coarsegold, CA 93614), for example, is the producer of the classic adventure series, *King's Quest*. While they make their games for the full spectrum of IBM machines, formats, speeds, and —whew!—graphics adapters, the whole process is getting a bit unwieldy. They have to account for slower machines that don't run at 8mhx or faster. They have to support all the graphics formats—CGA, EGA, MCGA, Hercules, and the new champ, VGA, as well as Tandy's own 16-color system.

Sound has also gotten problematic. The first PCs barely squeaked. The Tandy machines carry a much more capable sound card, with life-like sound effects. There's the Roland MT-32, Ad Lib, Game Blaster, as well as the IBM Music Cards.

Oh yes, there is still one other obvious area of noncompatibility for the compatibles, and that's the size of the discs. I use the 3.5'' floppies, while others may use the 5.25'' discs. Some software manufacturers supply both, others supply one, and offer the needed disk by mail for an additional $7.

Sierra has shown how a creative, demanding company meets this challenge. Their newest games, including the riotous *Space Quest III* and *Hero's Quest* offer state-of-the-art graphic adventures. Playing one of Sierra's games really engages you in the story. And the aesthetics of the sound and images are always interesting and clever.

Sierra attempts to support all possibilities, from the lowly CGA, all the way to the VGA. One recent change they made was dropping the low memory versions of some games. When I first started playing their games, you could get them in both 256K and 512K versions. Now, only 512 is available, And it's strongly recommended that these stellar games be played on faster machines.

Recently, I had an opportunity to try the outer envelope of graphics by using a Tandy TL/2 outfitted with a VGA card. Perhaps the major difference between VGA and the other color adapters is that it gives you access to 262,144

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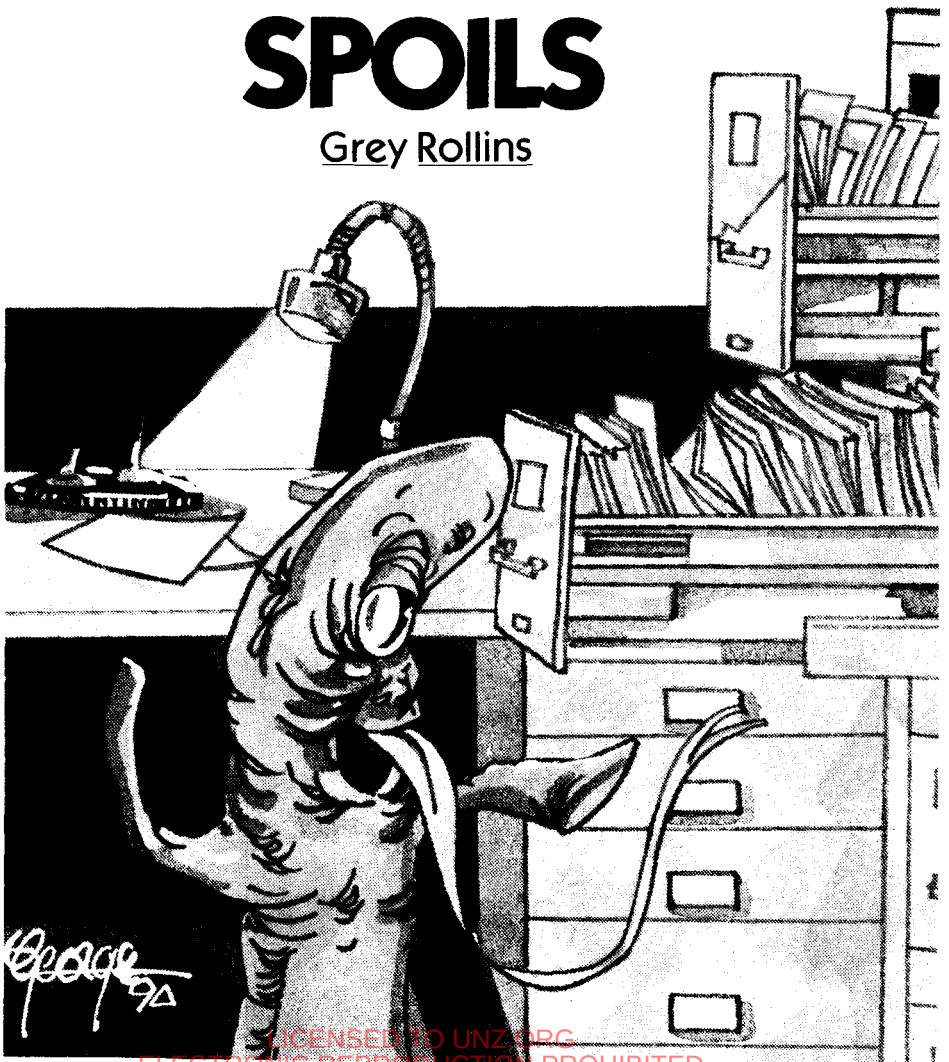
TO VICTOR GO THE SPOILS

Grey Rollins



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I wasn't hungry, but Martin Crofts was. Since he's my boss, what he says goes.

The owner of the corner deli knows Martin's tastes well. As soon as he saw me come in, he started on Martin's sandwich. He had me back out there so fast it made me dizzy. He hasn't liked me since the evening last fall when he caught me rooting around in his trash bin out back.

What can I say? I was hungry.

When I got back, I heard a woman's voice in the inner sanctum. Having standing instructions not to enter or in any way disturb him if the door to his office is closed, I placed his lunch on my desk and waited. I am very good at waiting on Martin. I get lots of practice.

Presently, the door opened and a woman came out. I got a good look at her as she turned to Martin and thanked him for taking her case. I detected traces of expensive perfume as she strode briskly past me and out the door. I don't believe that I registered on her consciousness—she seemed totally preoccupied.

"Oh, Victor! Did you see that gorgeous piece of meat?" His eyes rolled up in his head and he leaned against the wall next to the door into his office. "That was a special woman, I'm here to tell you," he breathed.

Reviewing what I had seen of her: taller than average—nearly six feet, long well-muscled legs, good pair of headlights, thick blonde hair. Martin absolutely loses all ability to think rationally around that sort. They don't do much for me, but that's no surprise.

"Not dead yet," I pointed out. "It's not polite to call them meat until they're dead."

Ignoring me, he exhaled slowly and a dreamy smile slid into place. "What a package . . . " He came back to life, clapping his hands together sharply. "Well now, what do you suppose she had for us?"

"Lunch?"

Martin's scowl threatened to make his eyebrows meet in the middle to form one continuous black fuzzy worm. "You have no taste, no tact, and no brains. Since you are playing at being obtuse, I will try ever so diligently to enlighten you, Oh leathery one." He ran his hand back through his thick black hair and bent over, the better to look me in the eye . . . singular, I have only one.

"What she had for us was money. Since the rent is due Monday and we have no money with which to pay it, the idea of being able to stave off the landlord's wrath appeals to me."

I could not resist the temptation to tease him. "Naturally, your elation is totally objective, Martin. It would be illogical for you to be interested in her physical attributes."

He huffed and straightened. "Business before pleasure." The very picture of wounded dignity, he marched stiffly back into his office. Three steps beyond the door, he turned on his heel and stared down at me, intense green eyes wide in the manner of a small boy.

"Did you happen to notice if she was wearing a wedding ring?"

After sex, it seems that money dominates the next greatest portion of Martin's thinking. This time it looked as though he would be nearly incapacitated

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mentally by the opportunity to think about both. I was beginning to worry about him.

Following him into his office, I set his sandwich before him. His eyes followed the plastic foam container as though I were trying to outwit him at a shell game.

Considering the rate at which he devoured his sandwich, I asked if it would not be more efficient to simply stuff the entire sandwich into his mouth at one time and use a broom handle to shove it down into his stomach. The look he gave me would have withered a para.

"Victor, try not to be so unrefined—at least while I am eating."

"You wouldn't be putting on such airs had that woman looked like the Wicked Witch of the West. However, since she more closely resembled Miss March in the magazine that you keep in the upper right hand drawer of your desk, you suddenly remembered your manners."

Martin appeared scandalized. "I keep that drawer locked! How the hell did you know that was in there?"

I unrolled a foot or so of my tongue, then slurped it back in. "I've been practicing picking locks."

"With your *tongue?*" He stared down at his drawer in horror.

"Well, yes. I thought it might be rather useful—"

"Victor! Do me a favor. Don't practice on my desk drawers for God's sake."

"I was careful," I said plaintively. "I dried my tongue on a paper towel before I started."

His eyes squeezed shut and he shuddered, oozing revulsion. He dropped the remnants of his sandwich back into the plastic shell. "Suddenly, I find that I have no appetite. Do you want the rest of this sandwich?"

I considered for a moment. "In a few days. Just put it outside on the window ledge. I'll check to see if it's tolerable by this weekend."

"I don't know why I put up with you, Victor. You're disgusting."

"You chose me, not the other way around," I reminded him.

"I didn't choose you, I inherited you. It's not quite the same thing." He leaned back in his seat, the hinges squealing in something like D minor, while the counterbalance springs confidently sang C sharp. "Either way, you're here and I'm stuck with you. So we might as well get to work. Maybe, for once, you'll earn your keep around here."

"Ready when you are."

He carefully wiped his mouth with a napkin before outlining the situation. It seemed the woman's name was Tabitha. She was the manager of one of the posh jewelry shops in the high-rent district. There had been a break-in the previous Saturday night and an assortment of jewels had been stolen—the total value coming to roughly six hundred thousand dollars.

The thief had outwitted the alarm system by carefully sawing a hole through the metal back door and crawling through it, thus obviating the necessity of opening the door and tripping the sensors. He had then pulled a piece of cardboard, spray-painted black, against the hole and taped it in place. In the dark back alley it was sufficient to fool a cursory examination.

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There were motion detectors in the front portion of the store, but none in back; it was believed that the sensors on the door and the lack of windows were adequate protection for that area.

The thief had then placed a Thermit bomb against the door of the safe and ignited it. At this point his luck ran out. There was an ancient oak desk under the safe. The sparks and spewings of melted metal dropped onto the wood. The desk promptly caught fire, along with the carpet. The smoke detectors went off and, being wired directly to the fire department, brought the fire trucks within minutes.

The door of the safe had been found with a hole in it large enough for a hand. All that was left inside were the ashes of some papers that had been put inside for safekeeping. The heat from the Thermit had been enough to cause the papers to burn. The assorted unmounted stones that were kept in the safe were missing.

Tabitha's name was first on the call list for emergencies, the owner living out in the country. She arrived to find a sooty, dripping mess—the blue carpet soggy from the fire hoses. Tabitha had spent a long, sleepless night with the inventory sheets, trying to determine exactly what had been taken.

Late Monday afternoon the thief had been caught, having been traced by the Thermit that he had used to burn open the safe. The jewels were recovered with the exception of the diamonds. The thief admitted to taking the stones he was caught with, but denied having anything to do with the missing diamonds. Suspicion immediately fell upon Tabitha.

The police had interrogated Tabitha. The owner was getting ready to fire her. In general, things looked very grim. Having seen the writing on the wall, Tabitha decided to call in a detective agency. That decision led her directly to us.

Martin leaned back once more, the chair repeating its discordant wail, and stared at the ceiling with his best Sherlock-in-contemplation look. "There are several possibilities here, Victor. One: the thief has the diamonds, but has them hidden in a separate place. Two: Tabitha—"

"Martin . . . Martin . . . *Martin!*" It took me three tries to break into his train of thought. I have learned from experience that he can go for hours like this, spinning ever more fantastic and elaborate theories until he finally arrives at the conclusion that everyone in the known universe is a prime suspect.

"You're being illogical. The obvious first step is to go over to the jewelry shop and look the situation over for ourselves. We must have more information before we try to determine who has the diamonds."

Martin sighed in that peculiarly pained way that he uses when he is trying to be patient with me. "As I was about to say, the second possibility is—"

Time to play dirty. "Martin . . . if we go over to the jewelry shop you might get to see Tabitha again."

There was dead silence for a moment. "Ah, as I was about to say, I think a quick trip to the jewelry shop is in order."

"I would suggest calling the police to request permission to snoop around.

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It would be mortifying to be arrested as looters."

His expression soured. "You have a point. I suppose Pete Sims would be the one to talk to." It took a while to locate Sims. Tiring of listening to Martin fume every time he was put on hold, I went back to my desk.

I daydreamed of my beloved Wanne, my para. We were to be joined as ortho and para, to paraphrase the human wedding ceremonial vows, when Martin's uncle decided I looked like an interesting pet and kidnapped me from my home planet. Years passed and I grew accustomed to my fate—alone among nine billion humans on Earth. Martin's uncle died of old age and my custody passed to Martin. There had been a difficult time adjusting at first, because Martin didn't want to be saddled with a three foot leather banana as a pet. He continued to resent me until I was able to use my superior reasoning abilities to help him solve a lucrative case. After I was able to help him unravel a few more cases he hired me full time as an assistant. I draw some fulfillment from the work, but I still yearn for my Wanne.

My reverie was rudely interrupted by Martin's hand falling on my head. At least he calls my top my head. I have long since ceased trying to debate the point.

"Ready to go, Victor?"

"More or less."

He bent over and examined me at close range. "You feeling OK? You're not hungry, are you?"

"No. I ate the day before yesterday. I am simply suffering from a bout of homesickness, compounded by loneliness. Add to that a dash of melancholy and pinch of the blues for spice."

He pursed his lips. "Sounds like you've got it bad—"

"And that ain't good," I sang.

Martin rolled his eyes. "Not much I can do for you there, buddy. My uncle never told me which planet he got you from. If we ever find out, I promise I'll send you out on the next ship going that way."

"So you say. What would you do without me here to do your thinking for you?"

He grinned wryly. "Probably go broke within the month. Ready?"

"I suppose," I said resignedly.

He picked me up and tucked me under his arm like an elongated football. It's not that I can't walk, but my legs are short and it's simply more expedient for him to carry me when we need to move more quickly than a snail's pace.

"Victor?"

"Yes, Martin?"

"Have you gained weight?"

"Watch the door frame, Martin. No, I don't think so."

"Remind me to put you on the scales when we get home. I think you're getting fat."

"I am the very picture of health. Slim, attractive—"

"Watch it, Victor. Don't get carried away."

I retaliated by giving him a rendition of "Pictures At An Exhibition" with the basses slightly out of tune. This is easy for me to do since I speak using a tympanum rather than vocal chords. I can effortlessly play all the parts of the orchestra simultaneously in much

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the same way that a stereo speaker accomplishes the feat.

Martin gave me a sour look. "You're butchering one of my favorite pieces of music."

"It's the fat man theme. You said I was fat."

"Well, for God's sake at least play the damned thing right."

I relented and brought the basses up to pitch. For a human, Martin really isn't so bad. He just needs to be brought back into line once in a while.

I don't like riding with Martin. As a matter of fact, I don't like riding in cars. There is simply no way for me to keep my balance standing on the seat unless Martin wraps the seat belt around me three or four times. That's about as satisfactory as sex with a cactus, to borrow one of Martin's pet phrases. I keep meaning to ask him if he knows from personal experience.

We arrived downtown only to watch some vacuum brain park his car so as to take up both of the last two available spaces on the street. It took quite some time to find another.

"When are you going to get around to making that harness you keep promising me?" I groused when Martin finally unraveled me from the seat belt and put me on the sidewalk. "I feel like a high-tech mummy with all that nylon wrapped around me."

"Soon."

"Right. The least you could do is cover the seat belts with velvet. At least that wouldn't abrade my skin so badly."

Martin gave a little half shrug. "You can ride lying down on the seat on the way back if you want."

"But then I can't see!"

Martin's only reply was a sigh as he started off.

I did a complete turn in order to look around. Trendy gift shop across the street called Presents of Mind, with a multicolored awning hanging over the sidewalk. Expensive cars parked in ruler-straight rows down the street. Our dilapidated death trap sitting forlornly between a top line Mercedes and the latest alcohol-fueled Porche. Martin's back thirty feet down the sidewalk.

Damn. I've told him time and again not to leave me like that.

I put my legs into high gear and started off in hot pursuit. For me, hot pursuit is about equivalent to a brisk walk for a human. Six-inch legs are not conducive to track star velocities.

Martin must have heard my feet drumming up the sidewalk behind him, because he stopped and waited for me. "Elephant legs getting a workout today?" he inquired innocently.

"They are *not* elephant legs, they're *my* legs," I said indignantly.

"Look like elephant legs to me."

This was his revenge for my half-tone flatting of the basses. "Pick me up, you overgrown sack of hormones!" My dignity was taking a sore beating from the amused stares of passerby.

He grinned down at me and swept me under his arm. My vision swam for an instant before steadying down. Looking at the world from a horizontal position is fine by me, but it takes a second to readjust.

It seemed like miles before we arrived at the store. Thank goodness I was getting a ride. It would have taken me about

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three seconds less than forever to cover that distance at my pace.

We were met at the door by a man wearing a blue business suit and a serious expression. Obviously the owner. He had that self-important air of the newly chic. Too cool to be cool, as the expression goes.

He cocked his head and studied me. "I've seen pictures of this animal, but I've never seen the real thing. Can he actually talk?"

After Martin assured him that I could, he went into the half Polly-wanna-cracker, half baby lingo that people use when they want to hear me speak for the first time.

I don't like being referred to as an animal, so I let him go on long enough to make a complete fool of himself before I spoke. "Not only can I talk, but I see that you have a mustard stain on your tie. You really ought to be more tidy when you eat." Not nice, I grant you, but I wasn't in the mood for his condescension.

His face colored immediately. "Uh, yes, of course."

Martin filled in while mustard man reinflated his ego. "Pete Sims said he would call and arrange for us to take a look around."

"Yes, I spoke to him. I'm afraid that your visit may be in vain. It pains me to say it, but it really does appear that Tabitha may have had something to do with the disappearance of the diamonds." He sighed. "And after I'd trusted her implicitly for all these years." He glanced self-consciously at his tie. "I have an important meeting with the insurance adjuster in about thirty minutes. I'll leave you with Tabitha."

We found Tabitha on her hands and knees in a ruined pair of jeans, cleaning up the office space in back. She seemed close to tears.

"Tabitha? Victor and I wanted to take a look around. Is that OK?"

I have grown to know humans well, sometimes better than they know themselves. When she looked up, I knew instantly that Tabitha was innocent. Her body language spoke of utter defeat and humiliation. Had she actually taken the diamonds, there would have been at least some small hint of defiance.

Unfortunately, I am not admissible as evidence in a court of law. My opinion was worth about as much as the charred remains of the desk.

"Oh, sure," she said with bitter sadness. "Help yourself. There's nothing left here of any value. Unless, of course, you happen to know of a market for melted ball point pens and warped doors."

Although Martin was unable to read the subtleties, he was powerfully moved by her aura of helplessness. He went and crouched before her, using his finger to wipe away a smudge on her cheek. "Tabitha, it'll be OK. Trust me."

She tried to smile, but failed miserably. "It just hurts to have Mr. Ryder turn on me the way he has. I would never have thought that he would be so quick to believe that I took the diamonds."

Martin took her hand and helped her to her feet. "Take a break and show us what happened."

She noticed me for the first time. She squatted so as to be on my level. "You're Victor, aren't you?"

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It is always a relief to be taken as a sentient being rather than a toy. "The one and only. There are something like twenty-seven extraterrestrial species resident on Earth, but I am currently the only representative of my type."

"And it's a long way home." she said faintly. "Well, it's good to meet you, Victor." She stood again. "OK, let's start with the safe."

She led us over to a concrete wall that looked more than a little worse for wear. A blackened and fused rectangle the size of a large book was all that remained of the safe door. She turned and asked, "Do you know anything about Thermit? The police seemed to think it's pretty nasty."

Martin winced. "That's an understatement. Thermit is a mixture of aluminum and iron oxide. It's difficult to get going, but once it's lit, you'd just as soon have the devil loose in your kitchen."

She nodded. "I got that impression."

Martin moved closer, reaching into his pocket for his keys. He keeps a tiny flashlight on his key chain for situations such as this. Bobbing his head back and forth, he grunted and scowled as he examined as much of the interior of the safe as he could through the irregular, fist-sized hole.

"The thief must have been wearing a heavy glove when he pulled out the stones," he muttered under his breath. "This door must have been cherry red after the Thermit burned through it."

"We tried to get the safe open, but I'm afraid that the door seems to be permanently welded shut. You'll just have to make do with the hole," Tabitha said.

Martin turned and looked down at me. "Want to take a look?"

"I suppose I'd better. Since I'm the brains of this outfit, it would help if I had observations on which to base my deductions."

"OK, genius, hop aboard."

He handed me his flashlight and laced his fingers together to give me a platform to stand on. Since my arms are really only vestigial limbs at best, the flashlight and keys made a heavy load. I whipped a length of tongue around them. This suited my present purposes much better anyway.

Careful not to brush against the sides of the hole, which would no doubt leave a nasty aftertaste, I threaded my tongue into the safe.

Twisting the flashlight around, I saw that there were indeed ashes. They had been stirred around, undoubtedly by the thief as he groped blindly for the stones. Pity. I might have been able to tell something had they been left undisturbed.

Other than the ashes and the undeniable fact that there were no stones in the safe, I could see little to be gleaned by staring into a dirty hole in the wall.

"OK, Martin. Put me down."

"How do you talk with your tongue stuck out like that?" Tabitha asked.

"I don't need it to talk. I have a thin membranous muscle which I vibrate to make the complete sound with no further assistance from my tongue or mouth."

"Weird," she said, then immediately blushed. "I'm sorry, I hope I didn't offend you."

"I can also talk and eat at the same time. Something that humans attempt

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daily, but never quite succeed at." My attempt at dry humor was all wet. She was simply not receiving on that wavelength.

Martin reflexively wiped his flashlight on his pants leg when I handed it back to him. "Indeed he can, but take my word for it. You don't want to be around him when he eats."

Tabitha frowned. "Why?"

"He's not content with food that doesn't at least have a little mold on it. A gourmet meal for him is to go to the city dump."

"You're just jealous that your food isn't as tasty," I retorted.

Tabitha looked at me, then at Martin, trying to tell if we were joking. "Really?" She was caught between fascination and revulsion.

"Really," I assured her.

"Maybe I ought to let you clean out my refrigerator," she said, her mouth twitching in an attempt to smile. Perhaps there was a spark of humor left in her after all.

"My pleasure. Just let my chauffeur here know when and I'll bring a napkin."

Martin was bending over, looking at the hole in the door leading out into the alley. "The edges here are quite smooth, Victor. I wonder what he sawed this with."

I shuffled over and stared closely at the lip. There were minute diagonal scores in the sheet metal. "My guess is that he used a silicon carbide abrasive rotary bit. One of those in a battery powered drill should do nicely. A fringe benefit would be that it would be somewhat quieter than trying to do the job with a toothed saw blade. It wouldn't do for him to make too much noise."

Martin nodded. "Sounds like a good theory to me. Maybe Pete will know more. I'll need to talk to him, anyway."

"What happens in the meantime?" Tabitha asked.

"Keep your chin up. The cavalry is on the way," Martin told her.

We looked around the shop some more, but the combination of fire, water damage, and people pawing through the debris had left little for us to see. We left Tabitha standing in the door of the shop and headed back to the car.

"She didn't do it," I told Martin from my secure position under his arm.

"I know."

"It looks as though the insurance company is putting pressure behind the scenes, trying to find out who has those diamonds so they can be recovered. I imagine they wouldn't like the idea of paying Mr. Ryder that much money."

"I know."

"On the other hand, without any reliable information as to the whereabouts of the gems, we're going to have a tough time proving that Tabitha didn't take them."

"I know."

"Martin?"

"Yes, Victor?"

"Are you going to ask Tabitha out?"

"Yes, Victor."

"That's going to be difficult to do if they put her in prison."

"I know."

I was a minor sensation at the police station, since it was the first time that I had been there in person. It seemed as though everyone in the building had

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to look me over. The consensus among the women was that I was "cute." I gathered from context that they were using the word in the same sense that they would when describing one of those ugly dogs with the mashed faces. You have to either laugh at them or with them—might as well make it with them.

Martin is considered to be quite attractive to female humans, but I have always been his ice breaker. Women who would not normally find it easy to start a conversation can open with a question about me. Martin takes it from there. Only this time his heart wasn't in it. I began to see just how hard Tabitha had hit him, emotionally. Martin is not exactly the love them and leave them sort, but I couldn't recall him ignoring someone as attractive as the stacked little Italian who kept trying to catch his eye.

If we lost out on this case, he wasn't going to be worth an empty sardine can. Lovesick, he was.

Marie, the pneumatic Italian, went scurrying off to find Pete, anxious to try to please the tall, black-haired man with the talking hot pepper. I could have told her it was wasted effort from her point of view, but humans are single-minded about such things.

She was much more efficient than whoever had tried to find him earlier in the day. It was less than a minute before I spied her bounding back toward us, literally towing a pot-bellied man with red hair.

Pete glanced at Martin's face, then at Marie. It took him no time at all to size up the situation. He patted Marie on the derriere and sent her off to attend to whatever she had been doing before Martin and I came in.

I had met Pete once before and had talked to him several times on the telephone. He looked down at me and grinned. The expression looked incongruous on his perpetually sad face. "I've got a doughnut I've been saving for you. I kicked it under my desk during the Christmas party and haven't bothered crawling under there after it." He laughed loudly and clapped Martin on the back, gesturing down the hallway. "Come on back and I'll show you what we've got."

As I walked behind them, I could hear Marie chattering excitedly in the background, telling someone named Susan how good looking Martin was. I doubt Martin heard it. His hearing isn't as good as mine. With his brain all awhirl with thoughts of Tabitha, I don't think he could have heard Pete's service revolver, either.

Pete's desk looked like the kind that would have a dozen doughnuts underneath. Probably a few shreds of last week's lettuce, too. The top was completely covered with wrappers from every fast food joint in town.

He balled up three or four of the wrappers and dropped them in a paper cup half full of watery looking tea. No doubt it was from the day before yesterday. He carefully placed his elbows in the newly cleared spot on his desk.

"Let's see here. You're wanting to know what we've got about that jewelry heist this past weekend. I got that file out and put it here somewhere." It took five more hamburger wrappers, but he found it. "Hmmm . . . one of those

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guys with two first names. Harvey James. Born January . . . you don't care about that. Let's see. Ah, yes, here we go. The transcript of his confession. Naturally, I shouldn't let you read this, but that's OK. If I did everything by the book, life would be boring as hell around here."

Martin accepted the transcript silently and read through it without stopping. It did not take him long. He passed it back to Pete. "Nothing. He claims not to know anything about the diamonds. If he is to be believed, he took every stone in the safe, but the diamonds just weren't there."

Pete shrugged. "It's not my case, so I haven't talked to the guy, but Norm says that he thinks he's telling the truth."

"Norm?" I asked.

"Norman Pasky. It's his case," Pete explained, then looked back at Martin. "If the diamonds weren't in the safe, then the next best bet is that the blonde broad with the name like a cat, uh . . . Tabitha, has them. God knows how she intended to cover it later. It was just her bad luck that the place got hit that night."

"I don't think she took them, Pete," Martin said grimly.

Pete held his hands up. "Hey, man, I don't know diddly squat. Like I said, it's not my case. You called and wanted to know some background info on the case. Since you and I have traded favors in the past, I went and . . . " he coughed delicately, " . . . borrowed Norm's file. Other than that you're on your own unless you want to talk to Norm."

Martin shook his head. "No, Pete. I trust you. It's just that it doesn't fit. Like you said—assuming that she did take them, how did she intend to keep anyone from finding out?"

"Martin, I've seen people do some damn strange things. You sit there day after day staring at those rocks, knowing that you'll never make enough money to buy one of the really nice ones. One day something just snaps in your head and you take one home in your pocket. Why not? You always wanted one."

Martin nodded. "I know what you mean, but I think Tabitha is smarter than that. Had she really decided to take them, she has enough brains to have arranged some kind of situation to divert attention. . . ."

"Like maybe having someone come in and stage a robbery after hours to confuse the issue?" Pete suggested. "If that's the case, it looks like it's working."

"I'll give it some thought." Martin stood, obviously preparing to go.

A thought flitted across the back of my mind, leaving behind a lingering feeling of uneasiness. I did not get a good look at it, but it left a question as a calling card. "Pete, what were the diamonds in?" I asked.

"Huh? Supposedly they were in the safe—that's the whole point."

"Surely they didn't just drop them in there all jumbled together. They must have been in something."

Pete nodded in understanding. "I gotcha. You've never seen how they handle raw stones? They take them and fold them in little squares of white paper. Most of the time, they just put those little pieces of paper in a manilla envelope."

The flittering thought peeked out

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from the shadows beneath the rock it was hiding under and gave me a satisfied nod, but would not let me in on the secret. "Thanks. That's what I wanted to know. I never bought a diamond for Wanne. We don't have that custom where I come from."

Pete looked distinctly uncomfortable for a moment. I've never been able to understand why humans get embarrassed when I refer to my alienness. They prefer to pretend that I am just a somewhat-odd looking human. I try to take this as a compliment, but it is difficult to do so.

Martin shook hands with Pete and thanked him for his time and trouble. As we passed back through the front office, I once more became a minor celebrity just by existing, although the crush of attention wasn't quite as bad this time. Marie tried again to catch Martin's eye, but he was having none of it.

I stayed in the office that night. Since I don't sleep, one place is as good as another to spend the night. I descended into a trance state, determined to get my hands on that elusive thought and squeeze the truth out of it.

Late the next morning, Martin came and sat on a chair in front of me, repeating my name softly until I came out of my trance. He looked haggard. It was a good guess that he hadn't slept much. It's not a good idea to take too personal an interest in one of your cases.

I blinked at him, trying to make my eye focus properly. "Yes?"

"Pete just called. He thought we might like to know that they are going to formally charge Tabitha at one o'clock this afternoon."

"So what you're saying is that if we don't come up with something substantial PDQ, Tabitha will not be in a position to pay us our fee. From the look on your face, I would also guess that you would be emotionally devastated."

Martin nodded. "That's about the shape of it," he admitted. Pounding his fist on my desk, he insisted, "She didn't do it. I just won't believe it. It's impossible."

"Nothing is impossible. Some things are just harder to believe than others," I quoted.

"Well, I'll tell you what. While you're trying hard to believe it, I'm going back to my office and pour a stiff dose of eighty proof thought stimulator."

It took some frantic thinking, but I managed to catch my rogue thought and wring its sneaky little neck. I marched into Martin's office just after twelve. "Get your keys. If you drive fast enough, we might get to the jewelry store before the police arrest Tabitha."

I didn't have to repeat myself. We were out the door before the echoes of my voice died.

We were half way there before he thought to ask what I had come up with.

"You won't like it, so I'd better not tell you."

"Victor!"

"If I'm wrong, you can still save face before Tabitha by not being the one to speak."

He threatened me with bodily harm, but I held fast—literally. It was a good

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thing I did, as I think we took several of the corners on two wheels.

We got to the jewelry store just behind the police. They had already read Tabitha her rights and were coming out the door as Martin ran up the street. Tabitha looked stricken, but was holding together.

I got a taste of what the football feels when the quarterback is going for a touchdown. The jarring of Martin's feet hitting the sidewalk kept my eye from focusing—the whole world looked like a kaleidoscope.

"Wait! Stop!" Martin shouted at the police when we got within hailing distance.

One simply does not tell the police not to do their duty while coming at them at a dead run, carrying an object under your arm that just might be a weapon. No less than three guns were drawn on us by the time that Martin skidded to a stop.

"Tabitha didn't do it," he panted, out of breath from running.

The tallest of the men looked down at me. "That's that talking critter. You must be Martin Crofts."

"Yes," Martin gasped between whoops of air. "Tabitha hired me to look into her case."

"You cut it a bit fine, didn't you?" asked the tall man. He looked exasperated. "Oh, all right. Tell us what you've got."

Martin set me down. "Tell them, Victor."

My heart was warmed by the faith he had in me. For all he knew, I was about to froth at the mouth and speak in tongues.

The tall cop leaned down. "Your name is Victor? OK, Victor, if Tabitha didn't take the diamonds, who did?"

"Nobody."

His left eyebrow rose menacingly. "Excuse me?"

"I said no one took the diamonds."

His other eyebrow went in search of its mate. "That sounds like nonsense. If no one has them, then they should still be in the safe. I assure you they aren't there."

"Actually, they are, in a manner of speaking."

He glanced over his shoulder at the other officers, his expression kept carefully neutral. He turned back to me. "OK, little fella, I'll give you exactly one minute to explain yourself. Then I'm taking this young lady and putting her in that cruiser and I'm taking her downtown. If you aren't very careful indeed, I may decide to take you, too. Something like obstructing justice may apply here."

Had I been wearing a collar, I would have loosened it. "What are diamonds made of?"

I had misjudged him. He got angry. "I don't have time for this!"

I was saved by Tabitha. "Carbon. Diamonds are made of pure carbon," she blurted.

"Right! It's really very simple. Harvey James put a Thermit bomb against the door to the safe. In spite of the fact that it's called a bomb, it doesn't actually explode. Thermit bombs just burn their way through anything that gets in their way. Once the Thermit mixture gets going, it reaches temperatures of almost 5,500 degrees—more than hot enough to heat the air inside the safe to a measly

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few hundred degrees, even with the safe door buffering the heat."

"Listen, runt, you want to hurry this up?" I had a bad feeling that I was going to end up in a cell adjacent to Tabitha's.

"*The diamonds burned!*" I squeaked.

"What!"

"There were some papers in the safe. They caught on fire, right? That proves that it was at least three or four hundred degrees, because it takes that to ignite paper. However, once ignited, paper burns at seven to nine hundred degrees, depending on what kind of paper it is. The combination of the paper burning and the heat from the Thermit would have ignited the carbon that makes up the diamonds. Just like burning coal, but more expensive. Depending on how much oxygen was trapped in the safe, the diamonds may or may not have burned entirely before he reached in to pull out the jewels, but the very fact that a hole had been opened in the door of the safe would allow extra oxygen to get in. The diamonds would then finish burning. They were kept in paper squares inside a paper envelope. That would have burned, too. It would appear that the diamonds were gone."

A puzzled look crossed his face. "Well, I'll be jiggered!" He looked at one of the other officers. "Mike, you went to college. Is what this critter saying right?"

"It's possible, Norm. I'll be damned if I can think of a way to prove that it's actually happened, though."

Norm turned back to me. "Well?"

"Vacuum out the ash that's left in the safe and examine it under a microscope. With luck, there will be some unburned fragments left."

Norm rubbed his Mount Rushmore-sized jaw for a minute. He clearly didn't like what I was telling him, but I'm sure that he knew that the case against Tabitha was far from airtight. He had to weigh his alternatives. "OK, little fella, we'll play it your way." He turned to Mike again. "Get on the radio and tell them we want the hardware wagon down here right away." He turned back to me "I hope you know what you're talking about, little fella."

"So do I," I muttered to Martin, ignoring the look on his face.

A form appeared before my desk. I had left the door to the hallway open and had not been paying attention.

"Do you like cheese?" Tabitha asked me.

"I'm part mouse. . . ."

She smiled. "Here, I brought you a present," she said, handing me a brown paper bag. "There's a block of moldy Swiss cheese and two truly worthless tomatoes in there. I do hope you weren't kidding about liking spoiled food."

"Just pretend that I'm a dog who likes to eat very leftover leftovers."

The door to Martin's office opened. "Victor, did I hear—*Tabitha!*"

She dimpled. "I just dropped by to thank you two for saving me from an awful fate. Victor was right, of course. They found tiny, charred remnants of the diamonds in the ash when they got it under the microscope. Mr. Ryder has apologized thirty-three times every hour for the past three days, saying that he knew I was innocent all along." She shrugged. "It makes you wonder, but at least things are getting back on an even keel."

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"But . . ."

She held out a bottle of better than average wine. "I gave Victor some of the worst stuff I could find in my refrigerator, but for you I bought a bottle of wine." She stepped up and kissed him.

Shortly afterwards, the office door closed.

Half an hour later, Martin opened the office door and gave me the rest of the day off. The smirk on his face and the girlish laughter in the background confirmed that they were, as Martin tactfully put it, getting acquainted.

I looked down at the feast that Tabitha had brought me.

Ah, if only Wanne were here. ■

FUTURES

(Continued from page 93)

colors, an amazing number that dwarfs the color capabilities of even the new 16-bit dedicated game machines such as Genesis and Turbografx.

Resolution is excellent. Though you'd expect games to look wonderful, straight text is crisp and clear. But it was the for the games that I wanted to try the VGA adapter and monitor. New games, such as *Hero Quest* and Lucasfilm's *Their Finest Hour: The Battle of Britain* display, on VGA, in almost cinematic detail.

Perhaps the best way to enjoy the VGA adapter is with a new program for Electronic Arts, *Deluxe Paint II*. (Electronic Arts, 1820 Gateway Drive, San Mateo, CA 94494) Here is something designed to take advantage of VGA's 256,000-color palette. You can create and alter images, paint, design and enlarge them, achieving a realistic, professional look in the finished product. In *Deluxe Paint II* the jagged edges of most computer graphics programs are banished. You can paint behind and in front of other objects without worrying about any bleeding. There's an assortment of brush modes to select, and a special color cycle lets you create animation effects.

But even if you have no serious reasons for such a powerful graphic program, *Deluxe Paint* offers more entertainment than most games. You can take images and rotate them about all three axes—X, Y, and Z—to create a 3-D effect. Circles can be turned into spheres, and you can zoom in for magnified views and then scroll around the side of an object.

It's the type of software that will make you wish you had a high-quality color laser printer. But—as seen on the VGA screen—the images look great by themselves, good for brightening your office while you do something mundane, like pay your bills. . . . ■

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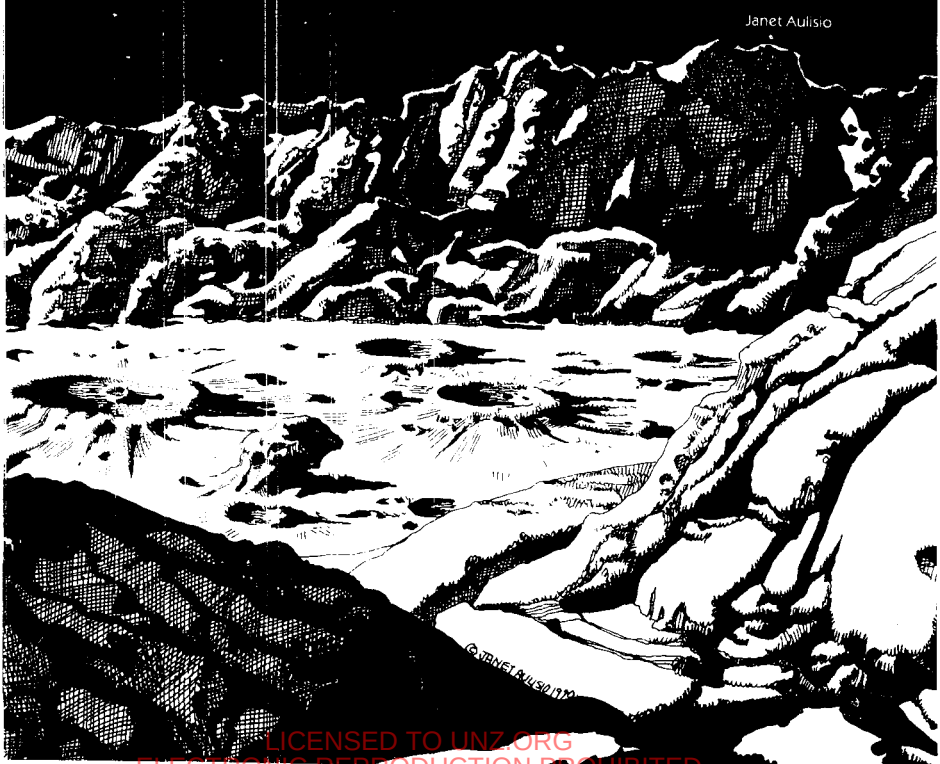
WANDERERS

Alexis G. Latner

No matter what culture an individual
comes from, adaptability
is the hallmark of our kind—
and it works in many ways on many levels.



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It had been months since John Clay took time away from the project for a three-hour lunch. He waited for Ramona in the restaurant's foyer. Globes of glass, aquaria, set in the dark paneled walls, contained vivid coral reef fish. John watched the fish swim around in their little worlds. For months, he thought suddenly, he had been immersed in the project like a fish in the water—as immersed and as oblivious.

Ramona rushed in and greeted him with an affectionate kiss. They were lucky enough to get a table by the glass that constituted one entire wall of the restaurant. She ordered crab legs. "You can pick over them for a long time and not look like you're just sitting around waiting for something dramatic to happen," she said practically.

"But we are."

The restaurant bustled now, filling up with patrons, all attentive to the view past the glass wall. People walked up outside, too, going to stand by the pilings at the edge of the Indian River. The wide expanse of the river shimmered in bright hot June sun. Ramona pointed toward the water. "Oh, look, there's a dolphin—two of them."

As soon as he discovered the pair of dorsal fins, John nodded.

"They've come to watch it too!"

Ever since Shuttle, two routes led to space: one for human and other delicate payloads, one for heavy and durable goods. The Argosy I vehicle represented the latter in a massive way. Unmanned, relatively inexpensive because it did not have to be man-rated, Argosy would carry the stuff of the future into space on the multiple shoulders of its booster rockets. John could see it even from here, towering over Merritt Island's ragged rug of sea marsh.

It reminded him of *Apollo 11*. On that occasion he had taken his first tour of the Center, with his parents. They saw dolphins in the Banana River from the window of the tour bus. That night they camped out beside the car, on the sandy shore of this same Indian River, with a million other people. Fueled with liquid hydrogen and oxygen, sheated in ice, illuminated by floodlights, the Moon rocket shone in the night.

"They know what it's all about," said Ramona. "The old-timers will tell you that the day they threw a wreath onto the sea, for the Challenger people, seven dolphins showed up, and they circled it."

He did not want to think about that old disaster. Not today. "Maybe the dolphins like the spectacle," John suggested, gesturing toward Argosy I.

"You sure do! How come you didn't scare up a visitor's pass?"

"This—is close enough for me. This time."

Excavating in the recesses of her last crab leg, she gave him a puzzled glance.

"I got some news this morning. I—"

The waiter materialized just then. Young, very blond, very chipper, he said, "There's a ten-minute hold! Can I interest you folks in Key Lime pie?"

As far as Ramona was concerned, he could. She accepted it with a radiant smile. As he walked away the young man gave her an admiring look over his shoulder.

Tart lime and dense sweet cream, the pie delighted Ramona. It had been a

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long time since John had taken her to a restaurant, split a dessert. He had been immersed in his work. He was lucky that she had not left him for a younger and more attentive man. And that might not be a good context for what he had to say today. Worried, he ran his fingers across the tabletop, Plexiglass, under which lay an assemblage of seashells on white sand.

"What news?" Appreciatively, she took up a creamy flake of crust—invited it onto her fork. "Is that why you invited me out for lunch and launch?"

"First the good news," John said slowly. "The situation looks good for getting durable goods into space—thanks to Argosy! So—the Array's been put on the launch schedule."

Ramona nodded vigorously. "Good—good! It's about time!"

"Then the—not exactly good news. Not for Phil Taylor. He was diagnosed with heart disease. Meanwhile I passed the major physical with flying colors. Now it looks like I'm going to be promoted—to project manager. That means—on site. Being there."

Ramona's eyes widened. She put down her fork. "That's great for the project. And for you. But I'll miss you."

"No. I'll marry you. Then you can come too!"

But she shook her head, abruptly pushed the pie plate away. "No."

That jolted him. He protested. "But you know what the Array means—you know what it means to me!"

"Don't you know what the sea and the sky and the birds and wind mean to me?!"

"The Moon is nature too!"

"You're a scientist. For me nature means this living world. I will not move to the Moon!"

He felt sharply upset. He had presented to her a solution as neat and necessary as that of an equation. She had immediately negated it. And unless another hold developed, the vehicle would take off now and in the middle of this argument, spoiling the spectacle for both of them.

The ambient background music broke off; the management had elected to pipe in the countdown instead. With a minute left to go, a cumulus plume of steam rose out of the fire and water under the vehicle. Voices in the restaurant chorused, "Come on!", "Go, baby, go!" Silver, tridentine on multiple booster rockets, Argosy mounted the air.

Ramona exclaimed, "It's not flying right!"

"What—" He saw it now. The angle of ascent. It titled north. But Argosy was not aimed toward a polar orbit! Reflexively he leaped to his feet. The vehicle slanted into the sky, the distance, leaving a jagged trail. The building's roof blocked the line of sight. The restaurant emptied, people streaming outside, lining the pilings beside the river to strain their eyes peering north of east.

Smoke stained the sky.

A radio-equipped exercise walker with antennas on his head announced, "They blew it up!" His hearers groaned. The antennas bobbed with the agitated motions of the man's head. "They blew it up deliberately because it would have hit Charleston!"

Military-type helicopters raced northward along the coast.

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This seemed patently unreal, the smoke, the crowd, the copters. The young waiter happened to be standing next to John with a linen towel still tucked into his belt. It fluttered in a light breeze. Winds aloft were no stronger than this: the weather had absolutely nothing wrong with it today. Except too much heat for June in Cape Canaveral. "Looked like a goddamn malfunction," John muttered.

Unhappily, the waiter agreed.

"She's down!" the walker with the radio informed them all intently. "In five or six major pieces, hitting the sea."

Under his suit, John sweated. Maybe heat had precipitated the malfunction.

Ramona had tears in her eyes and hands on her hips. "Why did the big dumb bastard have *do* this?"

Early the next morning, the Internal Information Office held a conference. Saturday or no Saturday, people crowded the auditorium. Researchers mingled with NASA managers and space industry reps, off-duty tour bus drivers and astronauts. No lives had been lost, but a dear payload of hardware and hopes had been blown up with Argosy.

On the big monitor, live television came in from search ships offshore. Seas seemed calm, sky clear, weather as hot and fair as yesterday. Karl Kaminsky of the Info Office gave a running slideshow commentary, like a fugue to the slow tempo of the underwater search displayed on the monitor. This part of the intact vehicle—slide #1— corresponds to an object located by sonar, lying on the seafloor. Divers spiraled down toward it.

Stress tied knots in John's stomach. Yesterday promoted to project manager. Today this. He helped himself to one of the local newspapers floating around the auditorium. Page One looked more garish than usual, the orange sunrise logo juxtaposed with a big, black end-of-the-world headline announcing Argosy's downfall. "Mullet wrapper!" John tossed the paper away.

Then he found a copy of *Pravda,* today's faxedition fresh from Moscow, shoved into his hands. Phil Taylor demanded, "What are they saying?" Phil jabbed a finger at the front-page photo of Argosy flying to pieces.

John skimmed the Russian text. "Looks like the truth to me," he replied. "Fairly accurate facts. Here's a sidebar about *Apollo*. The writer wonders whether the United States just suffered bad luck yesterday—or whether we have lost the art for making better rockets over the past forty years."

Phil nodded dourly.

For the third or fourth time, Karl replayed the launch videotape. The magnificent rocket thundered into the sky. It veered sickeningly on a jagged column of fire. Exploded into a pinwheel of smoke. John caught himself chewing on a knuckle.

"Sabotage?" Karl Kaminsky shrugged. "Of course it's a possibility. Terrorists of three different persuasions have already taken credit, in fact!" Then he fielded another question. "Frankly, yes. Not only was Argosy not man-rated, but the technical specifications of not-man-ratedness fluctuated through two administrations and four times that many budgets."

"And as a result the design had god-

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damn fatigue," said Phil with bitter certainty.

"The future?" Karl replied to another question. "First we fix the vehicle." A thin laugh trickled through the auditorium. "Until then nothing's gonna go up that doesn't have L-5 written on it!" Too true: no laughter. "As you all know, construction has started on the space base at L-5. Canceling it is *not* an option. It can make do with the Spaceplane plus Titan VII's. Maybe recommission a few obsolete boosters. Plus buy rides from the Europeans and Chinese. The Soviet Union has its own big fish to fry.

"Unfortunately, the L-5 base will tend to monopolize all available vehicles. Among many other likely casualties of this situation—" John found Karl looking his way. "The Lunar Radio Array got approved only this week, and put on the priority launch schedule. Now . . . "

In an unwanted glare of attention, John and Phil extricated themselves from the auditorium. But not before several people zeroed in on them to make sympathetic remarks. Then they had to explain that Phil was not out of a job and a ticket to the Moon. John was.

They walked across the mall to their office in another building.

"Goddamn," said Phil.

"I'm sorry."

"Sorry for me? Cancel that."

"I'm sorry about the project. All the work we've sunk into it. Now a royal setback."

"Remember the Hubble Space Telescope?"

"How many years before it finally got off the ground? Yeah."

A few pink wildflowers, stragglers from spring, punctuated the grass. So far the sea breeze kept the morning from being unpleasantly hot. Phil said, "Just between you and me, I wasn't looking forward to the part about being stuck on the Moon for however long it took to build the Array." Then he asked, "How about you?"

"Hadn't considered that. Till yesterday my expectations were in the lark mode." Every radio astronomer in the world had fantasized about using the Lunar Radio Array. A precious few weeks' worth of opportunity for highly productive work, with an admixture of fun, a lunar extrapolation of the traditional trip to Puerto Rico to use the Arecibo dish and get some slivers of Caribbean vacation. It would be a much different experience for the project manager.

In the office, John checked the electronic mail that awaited him in the computer. The e-mail included distressed remarks from his colleagues in the Space Radio Consortium, requests for inside information from various acquaintances, a sympathetic note from his elderly parents. Using the computer, John reviewed the Argosy-related items in the electronic media. That transection contained no information that Karl had not imparted. There was one scary picture of broken booster rocket falling out of the sky. Some freelance photographer had been out on a shrimp boat in the right—or nearly very wrong—place at the time.

Then the signal for incoming mail flashed. This one came from Schropfer, the director of the Consortium. Terse, it called a conference at the Center to-

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MORROW. MAKE EVERY EFFORT TO ATTEND IN PERSON OR ELECTRONICALLY. DROP EVERYTHING FOR THIS. BRING ALL REPEAT ALL TECH SPECS FOR PLANNED SPACE RADIO ASTRONOMY FACILITIES. DO NOT BRING ROSE COLORED GLASSES.

The details of space radio telescopes occupied most of the rest of John's weekend. He stayed late in the office Saturday, got up late Sunday. By that time Ramona had left the house to go to the beach. He felt slightly guilty. When he brushed it off, the guilt circled and came back to settle on another perch in his mind. He was still neglecting her. Yet had the project gone up on schedule and he with it, he would have missed Ramona more than flowers and wind. There would have been no real reason for her to wait for him to come back from the Moon, either. But now, with the project on indefinite hold, he would find time for Ramona.

With his morning coffee, John walked around in the house. He liked the house, an old bungalow in the city of Cape Canaveral. He would never have managed to make the place this habitable on his own. Ramona had intermingled his books and his pictures of rockets and radio telescopes with her Amerindian art and shells and feathers. Plants clustered around the windows. The house was not roboticized. The two of them opened windows, cooked, set alarm clocks and watered plants by hand.

John unfolded a bulky printout from yesterday. Plants, walls and all faded, supplanted in his imagination by the array of radio dishes on the plain on the Moon's far side. Seven great dishes, mobile on miles of track, aimed at a point between the distant visible stars: a radio galaxy. Each dish took in a slightly unique trace of data. A supercomputer meshed the data; it limned the lobes of bright matter spewing out of the radio galaxy's black-hole heart.

But the whole business existed only as plans. The Array was ephemeral as the equations and cost estimates that described it, and as easy to alter. Or cancel.

Ramona came back from the beach. He kissed her. "Forget what I said yesterday. What happened to Argosy changes everything. We can stay together longer."

"Maybe," she said quietly.

"I'm all but sure. The L-5's going to monopolize everything this country can launch for as long as it takes to fix Argosy."

"I found this on the beach." She handed him a shard of silver metal. John turned it over in his fingers. Sharp-edged, the sea had not had it for long at all. Ramona said, "Just before it went up—I didn't like what you said. We *are* married in every sense but white mens' law!" The American Indian blood showed in Ramona's features, but only if you knew what to look for. "Did you think it was a generous offer to legalize me if I'd go to the Moon with you?"

Warily John said, "That's just how the rules work. You have to be legally married to go with someone off Earth. Farside Moonbase would welcome a good technician like you, I know."

"You assumed I'd go. But it's not like following you to Arecibo or even Pacifica. It's the Moon."

"It's not as dangerous as Arecibo," he joked weakly. "No Independence revolutionaries."

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"That's not it at all! I thought about this all morning. The Moon is not our home. We don't belong there!"

"What?" His head hurt, crammed with equations, angles, figures, costs. Somewhat shortly, John said, "That makes as much sense as saying God would have given us wings if he'd meant for us to fly!"

"God," she said stiffly, "the Creator, put us on this Earth with the living land, the plants and animals and birds, and the seas."

He recognized Ramona's Indian oscillation. Her Indian identity peaked when white society in general or he in particular bothered her. When and if Indians bothered her she would go the other way. She had been raised in Oakland, California, mixed blood and mixed-up identity. "Honey," John said, "be reasonable. Your work helps keep the Spaceplane flying, and you're very proud of it!"

"It goes and it comes back. The Moon is—maybe it's different for white people," she said sternly. "For white men! You've always been cut off from nature, from the land, leaving Europe where your ancestors lived and died, and then moving in on us over here—and wasting the environment!"

He objected. "Don't blame me for that!"

"Land—you see, it's holy. Where you live, and who you live with, like the ecosystem. The Moon is alien land. It's lifeless. It can't be related to."

"Look," John said in exasperation, "The Moon is beside he point. The project is grounded!"

"Not if you can help it!" She gestured at the pocket computer. It perched beside his breakfast plate on the table, working, tiny icons flashing. "I know you. I thought you knew me, who I am. You even read the books I asked you to. Can't you see that moving to the Moon isn't an Indian thing to do?"

He could have adduced the Mohawk construction workers on the girders of the L-5 base, or the Navajo slated to go to Mars. Then the phone beeped urgently. He did not need the Indian Oscillation, not *today*. He snapped, "You're not really an Indian," and turned toward the phone.

John found Phil Taylor's craggy face on the screen. "Schropfer is coming in on the Frigatebird at two, and you're the welcoming committee."

Ramona heard that. So John left without saying anything more.

Puffy, thundery, showery clouds dotted the sky now. More flyable than old Shuttle, the spaceplane weaved between the clouds, heavy and graceful. A sonic boom rolled across the coast. The clouds and the sky and the plane made a striking scene and John automatically wished for Ramona to see it, too. Then he remembered that he had left the house on a damnably bad note.

Touching down, the spaceplane pulled to a screeching halt. Attendant mechanics rushed to it. John waited. After a while Schropfer emerged, staggering under the impact of the gravity of Earth. The robot shuttlevan whisked them to the main conference building. By then a cool downdraft whipped across the mall. Schropfer paused. Owlishly he contemplated the thunderheads in the wide sky. "One misses weather."

They got as far as the main auditorium before Schropfer had to sit down.

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Karl still presided, more disheveled than yesterday. He addressed the fresh footage of the search operation on the monitor. The divers had found a booster rocket engine, very interestingly mangled. "Engine in cold water," Schropfer grunted. "Contractor in hot. Help me up, I seem to have sat down in a gravity well!"

They found the small out-of-the-way conference room, and the rest of the executive committee of the Space Radio Astronomy Consortium waiting there, with one exception. Baltazar had managed to miss his flight from Ithaca. Two members had flown in from Green Bank. The last two attended in the form of faces on visiphone screens. Their research had taken them to VLBA Pacifica.

With something of the air of a physician arrived at the hospital waiting room to talk to the anxious relatives of an accident victim, Schropfer said, "Six months to troubleshoot the vehicle. Six more to fix it. Another one point five years to get the L-5 backlog out of the way. Add six months for nonspecific snags and bad luck. There's my guess. And I guess good." With that, Schropfer tottered to a chair and collapsed into it.

His prognosis precipitated a round of ventilation.

The Very Large Array in New Mexico lay in ruins for lack of funding. Ancient Arecibo was still creaking along. A few other ground-located radio telescopes retained some degree of viability, most notably the several Very Long Baseline Arrays strung across the most uninhabited quarters of the globe. But radio-frequency communications and noise saturated the Earth nowadays, a miasma that meant the extinction of ground-based radio astronomy. The science had to move to space. Promises to that effect had been made by the government.

"Think of government promises as paper currency," said Schropfer. "Worth as much, or as little, as the government decides in its infinite lack of wisdom. Space installations will happen. Not as soon as we planned. Jen, Zhuxai. I overheard a resounding thud last night. It was Tiger Lily hitting the bottom of the priority list."

"Damn it all!" Jennifer exclaimed. "How many delays have there been already?" Her Chinese colleague looked glum.

The Chinese had been launching satellites for long-wavelength radio astronomy: the Spider Lily series, bundles of wire that bloomed into receivers for the radio waves meters long. Simple instruments, but effective, as very low frequency radio astronomy had never been doable on Earth at all. Long radio waves from the cosmos bounced off the Earth's ionosphere. After the Spider Lilies the next projected step had been a vast deep-space antenna, a cooperative venture of American and Chinese scientific interests, to be constructed within the next five years. It would have been called Tiger Lily. On the verge of crying, Jen said, "I don't want to read about it in the *Astrophysical Journal* when I'm eighty years old!"

Standing by the window and watching a thundershower in progress, John brooded. He kept himself physically fit. But he had been thirteen for *Apollo 11* and thirty for *Challenger* and had now

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passed fifty. If the Lunar Array slid many more years, John would develop heart disease like Phil Taylor, or some other infirmity of advancing age, and be grounded, too.

Schropfer finally said, "It's the L-5 station, meaning industry and glamor, versus little science 'uns like us. Any bets as to who'll fall out of the back end of the wagon? No? OK." He fidgeted, seemingly finding the chair too hard on a backside that had gotten used to the Space Station's low gravity. "Now, we happen to have that one thing going for us. We're small. We might manage to leapfrog *ahead* of the L-5 parts and parcels. Which is why I came right down without benefit of reacclimitization in the centrifuge upstairs." He jerked at his shirt collar, loosening it. "They probably shouldn't let fat middle-aged bureaucrats shortcut the process like that," he added.

"Leapfrog how?" John asked quietly.

"Downsize to where we don't displace enough payload to bother anybody."

There were noises of consternation. "We're bare bones already!" said Phil.

"So we shake down the bones. Viz, do we really need a superconducting supercomputer? Cooling shell's too damn heavy."

"Do we need an inhabited site at all or will an automatic facility do the job. That's the ultimate reduction, isn't it?" said John. No larking on the Moon, just streams of data relayed through a lunisynchronous satellite.

"I don't like this," said Kris, from Easter Island. The connection seemed to be getting worse. The screen snowed and made her words hard to understand. "Downsizing, cutting corners, automating. Is it really necessary?"

"Damn right," said Schropfer, "While the government's commitment to radio astronomy is still worth something. There's a round of inflation coming on, mark my words. More promises meaning less."

Outside the rain had stopped. The damp green contours of the landscaping framed an oval lake. One small tern circled over the lake. At intervals the bird precipitously dived into the water and reemerged in a flash of wings, with a minnow in its bill.

John would not have noticed the tern if he had never loved Ramona.

For the rest of the day the tern stayed on his mind, a twisting little bundle of guilt, circling, abruptly plunging little shocks of pain into his soul. He finally got home after dark. Looking into the bedroom, he found Ramona sleeping. John leaned heavily against the side of the door.

The tangle of her long brown hair told him that she had been restless before falling asleep. The sheets were tangled around her body, too. He wanted to wake her up, make love to her. But that would be unfair—more like an act of hostility. She had to be at work at the Center by 7 A.M. John left the house and headed for the beach. There he headed south toward the glittering hotels of Cocoa Beach. Over the sea, some moonlight leaked through clotted cloud cover. The Big Dipper lowered, in the west, over the lights of the city of Cape Canaveral.

He had not changed clothes. His tie dangled from the pocket into which he

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had stuffed it. He held his dress shoes by the fingers of one hand. Absentmindedly he strayed close enough for a wave to catch his bare feet. It got the hems of his slacks wet. Ghost crabs scuttled across the sand, as soundless and erratic as uneasy thoughts.

Ever since childhood and *Apollo,* he had wanted to go into space, to touch a strange other world: if not a glory ridden moon of Jupiter or Saturn, then at least the Moon of the Earth. He would have gone as readily after *Challenger* as before. But by then it had become clear that he would never be an astronaut. He became an astronomer instead.

The Moon hung over the sea, gibbous. The terminator, sunlight's edge, seemed to follow the contours of the craters. In that bright imperfect Moon, the past, the future, his dreams and reality fused: to create a radio telescope on the far side of the Moon, shielded by the Moon itself from the radio noise of Earth. To go into space, only as far as the Moon, and all the way to the most distant radio galaxies. It was doable after all. Because it did not have to be an Array.

He went home and turned on the computer. With it, he connected to the national space science data base.

Ramona came into the study. "It's 3 A.M."

"Did I disturb you?"

"No. I just woke up."

Loosely wrapped in her bathrobe, she looked worn out and vulnerable. John remembered the tern. "Ramona, I was thoughtless on Friday and inexcusably cruel today. I am sorry."

Eyes wide and dark, she answered, "But you were right. Indians belong. Somewhere. I've moved all my life, California, Minnesota, Florida. I don't belong anywhere. A little to Europe. A little to Apacheria except it doesn't exist anymore. I mean, the only sense of home I've got, is nature, the Earth." She let him embrace her, as she said, "Don't tell me to leave!"

"I'm sorry."

"Can I ask, not tell, ask you, not to go, or maybe not forever?!" He held her tighter. "It's something I have to do."

She sighed, he felt it, almost a shudder. "Why?"

She did not want a rational answer. He could not think of any other that would be real to her.

At 8 A.M. John returned to the Consortium's meeting room, clutching a cup of coffee. He had the bad-night, awake-by-virtue-of-caffeine shakes. No doubt many other people at the Center did too, today, only three days after the Argosy failure.

Schropfer listed downsizing measures. COMPUTER. He starred that. "No superconducting supercomputer for us!"

Phil Taylor said, "I hate to tell the able-bodied what to do. But husbands or wives on site. None."

The dryerase marker squeaked. "Plural of spouse. Appropriately." NO SPICE. Schropfer starred that one, too.

"Mine won't go to the Moon anyway," said John.

Schropfer grunted. Then he wrote SPECS on the board. He handed out computer printouts. "Here's my compilation of what we discussed yesterday. Degrading the technical specifications."

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John refused his copy. "No. That's what got Argosy into the water in eight pieces."

"What else can we do?" Schropfer shot back.

"Try no array."

"I beg your pardon?"

"What else? A ham radio?" demanded Baltazar. In rumpled and somewhat mismatched clothing, he had just made it in from Ithaca. He seemed distraught about the Argosy affair. Yet Baltazar, at thirty years of age the youngest member of the Consortium's executive committee, could wait longer than any of the rest of them, if it came to that.

"Jen, we could string wire out in several directions on the surface of the Moon. Just by sending people out with spools. Your long wavelengths don't need an instrument more exacting than that!" John spoke rapidly. "There's no weather to blow poles and wires down."

Schropfer looked sturdier today. Schropfer looked quizzical. "You want me to tell Washington we'll build the Tiger Lily space antenna on the Moon, by hand?"

"Not around an existing base," said Jen. "I thought about something like that. But the bases all have people trooping around, prospecting geologists if not full-blown mining operations. And VIP tourists even!" She snorted.

John said, "First—Zhuxai, your backers in the People's Republic, how would they react?"

"They can relate to doing things so simply!" The Chinese astronomer nodded vigorously.

Phil Taylor looked discontented. "The Lunar Array turns into a mess of wire for low frequency studies?"

"It's better than nothing!" Jen retorted.

Baltazar groaned aloud, as if in pain. "That's just too peripheral!"

Schropfer said, "That does leave the rest of the radio spectrum!"

"No. Wait. Throw out the VLA model," John said. "Use Arecibo instead. Pick a sturdy crater. Build a dish in the crater, and a movable feed in the dish. The gravity's so low that the feed can be more mobile than Arecibo's. Catch a somewhat bigger portion of the Universe. Of course we'd locate the dish south of the Moon's equator—we'd like a good look at the galactic center!"

"Still . . . " said Phil.

"Phil. It'd be a beginning. Mapping fainter structures of the Universe that we've never even seen before. Plus studying the very low frequencies on the other side of ten megahertz. We can string the wire for that near, or around, the dish, something like that, and manage not to trip over it, at least not too often. Then some day — the Array will get built."

"Hm!" Schropfer whipped out a pocket computer. His stylus scurried over the tiny keys. "No tracks. No six or eight separate freestanding dishes on said track. Less need for data crunching if it's not interferometric. Very low frequency studies as a bonus." The tiny computer spat out a strip of paper. Schropfer studied the figures on it, with dawning approval. "Construction phase will be shorter. Significantly!"

"But there was stuff we had planned, we need a large array," said Phil. The Lunar Radio Array had been his idea,

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ten years ago. "The detail that an interferometer registers . . . " Kris and Elliot seemed less than thrilled. Baltazar ran his hand through his hair, which then stood on end desperately.

"The window for radio astronomy is being closed on us," said Schropfer. "Not by nature but by politics with some bad engineering mixed in." He sounded utterly serious. "We've got to get something shoved through the window fast. Remember what happened to the planetary scientists before the turn of the century? They got stuck with a thirteen-year-gap between probes. But at least they had the Voyagers out there. And that turned out to be a hell of a lot better than nothing."

John and Jen and Phil nodded.

Indians did not care much for Thanksgiving, she said. They spent that day at Merritt Island National Wildlife Refuge instead. Early in the cold clear morning, he drove the car on a dirt road past ditches and marshes alive with birds, flocks and masses of them.

He had been in Houston, training, for the past two months. He had missed Ramona desperately. Today she looked much as she had when they first dated, wearing old neat jeans and a flannel shirt, and watching the world in general and birds in particular with serious attentive eyes. Years older than then, though, she had silver threads in the brown hair at her temples, and lines of character on her face.

"How long exactly?"

"Exactly two weeks," John said with difficulty, "until I fly out on the Frigatebird."

"It'll be a busy two weeks, I bet," she said quietly.

She was right. John had this last chance, this day, to make a desperate peace with her. He wanted more. He wanted a viable marriage. Not exactly May-December, but June and November. Science and nature, man and woman. He did not know how to balance the equation. The tension on both sides made it hard to talk at all. "How've you been doing?"

She reflected. "OK. Work's been good to me. And people have been sympathetic — not critical of me or you either — they understand why I'm staying, and you have to go to work on the dark side of the Moon. Oops. Far side."

"The far side is the dark side of the Moon, as far as the radio noise of Earth is concerned."

He parked the car. They got out to walk on the trail toward the marsh observation tower. A mixed flock of ducks dabbled on a pond beside the trail. Duck tails stuck out of the water at various angles. How long had it been since they went birding together? Too long for an activity that he liked and she loved.

Together they climbed the tall, sturdy wooden tower. Enough wind blew through it to make them shiver. On every side the land and water teemed with birds, flocking, wading, feeding, noisily pleased with life on this fall morning. Ramona scanned the marshes with her binoculars. "Ooh! Ducks and herons all over the place. And I see a wood stork."

At least he had not forgotten how to keep the company of an avid birder. Patiently, he listened to her report discoveries which, without binoculars and

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knowledge like hers, looked hardly less anonymous than pills on a gray/green/brown wool rug.

The venerable Vehicle Assembly Building cropped up on the otherwise featureless horizon. They were rebuilding Argosy in there. Next time around, the booster rockets, having been redesigned as they should have been made in the first place, would work right. The sky over the VAB was wide and clear, a sea of cool air.

John caught sight of a high and distant dot. It angled closer, a swift bird with backswept wings, wings that sliced the sea of air as effectively as the flukes of dolphin it its own element. He put a hand on Ramona's shoulder. "Two o'clock high. Is that a falcon?"

"Oh—! John! It *is!*" The raptor charged lower, higher, hunting breakfast. Galvanized, Ramona tracked it. John admired the falcon. He admired the curve of Ramona's back when the bird had spiraled out of sight of his unaided eyes.

They returned to the car. "Only my third peregrine!" Ramona sighed happily.

"It's a good sign." Starting the car, John activated the heater. Mentally he had begun to organize words. He hoped that premeditation would not invalidate what he intended to say.

The nude bathing season was decisively over, the beach, at this hour, thinly populated with well-clad walkers like themselves. The underlying tension of the day propelled them all the way to the local landmark, what remained of a wooden barge. It had wrecked many decades ago. Sea-worn and barnacle-ridden, the artifact of transportation technology was dissolving back into nature.

Ramona attached her binoculars to a distant speck of bird over the sea. It might be a gannet, she announced. The prospect absorbed her. John scanned the shore's white curve to the south, the Cape. He studied the barge, the sands and the wrack of the sea. Finally, he took a deep breath to steady his nerves. "Do gannets migrate?"

She nodded. "They summer near Nova Scotia — in absolute droves."

"The falcon was migrating down the coast. Wasn't it?"

"Um-hm."

"Can we talk?"

Ramona took him by the hand, and let him to a big chunk of driftwood. They sat there and huddled with each other against the wind from the sea.

He said, "I don't know if I'll like — even be able to stand—being there. I won't be doing my science, either. I've got to see that they get the dish built right, so the science will be doable!" He brought her hand, which felt cold, into the warmth of his jacket. "You once asked me why I had to go." Without further preamble he plunged into what he had been planning to say. "Imagine this. Sea creatures wandered onto the land and breathed air. They learned to walk and run and regulate body temperature. Then they ventured into the air. They flew. And mastered the air. Became the falcon."

She listened.

The surf broke around the remains of the old barge, billowed through a hole in the wood, sparkling in the Sun. John wondered if dolphins had seen the old shipwreck unfold. "Dolphins too. One

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kind of air-breather went back to the sea again. And there they wander and wonder still . . . . You're right: they know what launches mean."

Ramona nodded. They were on the same wavelength today. That had not been the case for months.

"Even plants peregrinate. They managed to colonize the land when it was barren as the Moon! Maybe we, men, Europeans, don't always wander because we're apart from nature. Sometimes it's because we're part of it!"

He had moved close to her world now, as near to her reality as he had ever found himself. Then he briefly stepped into it. "Maybe it's even more primeval than that. The Creator made us all wanderers."

The religiosity of that statement, coming from him, surprised her. Ramona sat still for a while and watched the waves. "Then it's holy."

As lightly, John stepped out of hers and back into his own view of reality. "It's—non-trivial, most definitely. I was having strange dreams in Houston. Some of 'em scared me."

"Tell me?"

He remembered tangled skeins of dreaming, about spacecraft and radio telescopes, some of it nightmarish: explosion in the blue sky, a wreath floating on green water; or narrow gray confines of a metal habitat blending into the wide gray moonscaped, unrelenting gray with no reprieve of green or blue. Chromatic claustrophobia. On the other hand, he had dreamed, not unpleasantly, about the L-5 space base.

"L-5? Why so?"

"I'm going to be doing an oscillation—spending a week in L-5 for every three on the Moon—so the body doesn't forget about full Earth gravity."

Four pelicans flew over the dunes, graceful big brown birds, in the sway of Earth's gravity, but not trammeled by it.

"By the way," said John. "The setback with Argosy scared them. The line of supply to L-5 got a hellacious kink in it then. They were rationing tools and food and even air for a while. It was uncomfortable. Now they're planning to shift the base toward self-contained, autonomous ecosystem. Plants and all—I hear somebody sent some Wandering Jew up on a Titan VII among their personal effects. The stuff survived getting flattened by 12 g's. Now it's thriving."

Ramona laughed lightly. "That kind of plant would!"

"They really are planning to ecosystematize L-5. Plants, fruits, vegetables. Aquaculture maybe—fish farming. And they may even factor in some pretty fish, and apple trees, and birds," he said. "Because people like them. It'll be something of an aquarium in space, a miniature ecosphere."

"You think people are smart enough to make it work?"

"Maybe. It's worth a try."

"You're right."

"I started dreaming about flying. Like a bird."

"Flying?"

"Sure. The L-5 structure really is big. Gravity ranges all the way from zero to Earth full. And there's recreational space in the middle. Room in which to fly, to somersault, to tumble. People love it. I talked to some who've been there."

"I've always had dreams like that,"

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she said wistfully. "Flying like a bird! Dreams where it takes work to get up off the ground, but then I'm up, I'm flying over things. Even under things like clotheslines and bridges."

"I remember, you told me about your flying dreams once. When I woke up from mine—I thought you'd like doing that. Would you?"

She looked at him, sharply. "That outfit is going to be impossible to get into unless you know somebody *and* are extremely qualified!"

"You do," he said dryly. "And you are. They need good technicians. And people with green thumbs."

"Are you serious?"

"I am as serious as I've ever been in my life! In Houston, I developed some connections. You can come to L-5. I would be with you for one week out of four, at least. Maybe more when the project goes well. From L-5 you could see the Earth, as well as the Moon and the stars."

Ramona blinked. "But—what about the house?"

"Jen's niece just landed a job at the Center and needs a place to live. She'd be happy to rent our house. Very nice, responsible young woman. An engineer."

"Oh my, you've thought of everything."

"I tried. But I'm not telling you what to do. I'm asking. Please come to space with me."

She watched the sea. She pointed out three small shorebirds, busy on their toothpick legs, with white bellies and a marbling of gray at the throat. Turnstones, whose fragile wings had brought them from the Alaskan Arctic for the winter. "You're right about the Creator's wanderers, although I'm not sure that you believe what you said. Yet. Anyway it's true." Then Ramona said, "But dolphins came back to the sea. So did these birds."

John's free hand was curled in a jacket pocket, together with something damp and sandy. He pulled it out. "I found this on the beach—while you were watching the gannet." He offered her a calico scallop shell, unbroken, white shell with purple tracery. "I, or if you go too, we, will come back. I promise you that."

Her hand folded around his fingers and the shell. She smiled. Then she tilted his hand to look at his wrist watch. "Can we watch a Frigatebird now?"

They turned to face the Cape to the south, and waited.

"Hmm. Maybe it's running late."

"My bird never runs late," she said firmly. "At least not for technical reasons."

"OK. My watch is fast."

It made a dramatic appearance. The big, dark, flat plane charged out over the sea. Ponderous but capable, it climbed into the sky. A wave of sound, the roar of the ramjet-engines, broke over the beach.

Laughing, Ramona hugged and kissed him. "I will go too!"

Sharing her binoculars, they succeeded in seeing the rocket flare when the scramjet came on. It traced a thin bright arc in the sky. Riding fire, the Spaceplane angled up toward the margin of the ocean of air. ■

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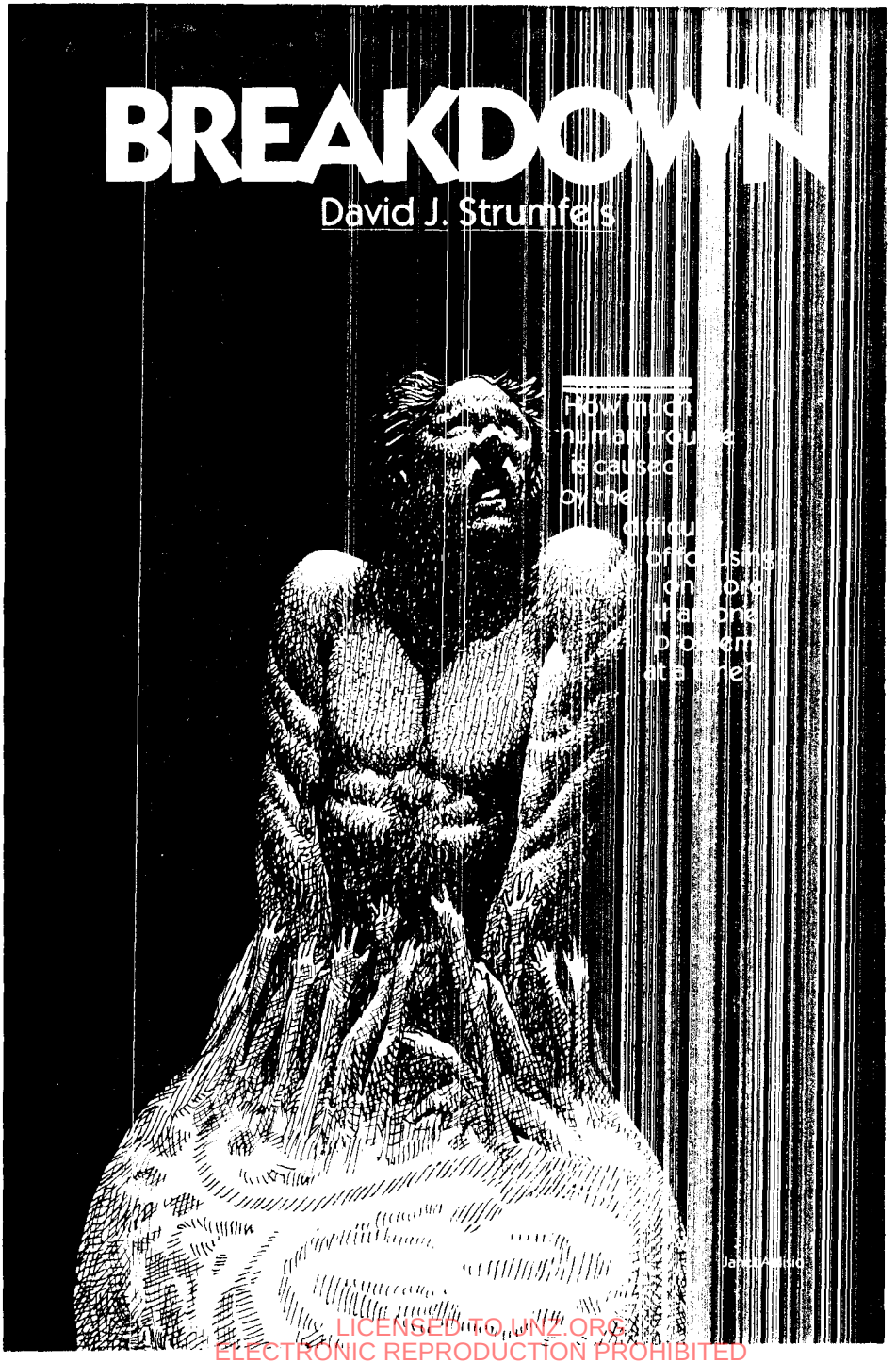
BREAKDOWN

David J. Strumfels



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The rhythm of her breathing seemed to mask out every other sound, every other sensation, in the tiny room now. The mechanical aura of the sound was unmistakable, like the beating heart of a bad horror film; still, Dan reminded himself that it was a stubborn act of life by Helene's otherwise motionless body. Sometimes he even found himself breathing along with the rhythm, as though by doing so he was encouraging her. The truth was, however hopeless the doctors told him it was, he could not bring himself to accept it. Helene was alive in there somewhere, a spark of life and consciousness that could no more cease to exist than the matter of her body could cease to exist. Why couldn't they see that? Doctors. Human beings were just pieces of meat.

He erased the tears again, smudging the pain in his soul. A trembling hand went to the withered form, slid down matchstick arms, avoided the stained patches of gauze where metal and plastic met skin, and held the fingers loosely in his. The flesh was still warm all right, even if there were no muscle responses anymore, even if nobody seemed to think it was of any significance. Damn it, *everything* was of significance.

Of course Dan knew he was deceiving himself, that Helene was far beyond even such simple acts as recognizing his presence. The pirouettes of death her brain cells were performing were slow but they had been going on for more than a decade, and by now there was little left beyond the most rudimentary responses. What had to be done was done by tubes; tubes brought nutrients to her body, removed waste products, kept vital passages clear. Tubes connected to other tubes, ultimately connected to bags which were periodically changed. *Rhythms of death.* Strangely, in a way he preferred her like this; the way she had been before, her mind and muscles twisting scarecrows of confusion, had been violent hell compared to this peaceful one. This way at least one of them was relieved the agony of watching her die. *I suppose I should be thankful.*

No, she did not recognize him at all anymore. She simply stared at him from hollowed out sockets of eyes, the same way she would stare at any other object that happened to intersect the direction her pupils were facing. Perhaps it was just as well, for he didn't recognize her either; that pitiable, drooling, skeletal wreck huddled on the bed could not possibly be the vivacious woman he'd once known, could not be Helene. No, Helene had died years ago, and the doctors had dredged up this creature from some other ward to replace her. That had to be the explanation.

He realized he was holding the creature's hand, released it.

He tried to control himself, failed.

"Senator Ruiz?"

He patted the nurse's shoulder reassuringly. "It's OK. I'm all right. Is there a place where I can—freshen up? Oh, and would it be too much for someone to call a taxi? I'd do it myself but I'm rather in a hurry."

The nurse broke into melting smiles and hurried off to obey his wishes. He watched her retreat with a cynical grin and a head shake. *Still got it in you,*

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haven't you? he thought and remembered that, Helene at his side, he would have used *it* to go all the way to the White House.

Such were the plans of once was and should have been.

When he was satisfied with his appearance he found that it had indeed not been too much trouble. Spitting the address at the driver he booted his laptop and reviewed the notes he'd made in preparation for his meeting with Lejune. Tried to review. Instead of meeting his eyes though the words flew around him like a swarm of gnats. No, not gnats: bees. They stung at him with relentless barbs of conscience. They defended the hives of his lies from the truth. However much charm and rhetoric they oozed, their message still came down to an ugly truth; he was going to help the Toombs-Billings coalition in its campaign to once and for all abolish all meaningful genetics research in the country. That's what he was going to do and Lejune would see through all the obfuscations instantly.

It would cost him Eric's friendship, just as it had cost Helene her life.

Too soon the taxi pulled up at the address and the driver was smiling for his fare. Dan felt his fingernails press into the palms of his hands and the tang of metal in his mouth and wondered, for the ten thousandth time, how things had gotten to be like this.

If politics was the art of synthesis then Patrick Toombs and Theodore Billings had to be counted among the greatest politicians in history. Both men, otherwise as alike as Jesse Helms and Ted Kennedy of the previous generation, had recognized the disfavor science and technology had fallen into among their respective ideological camps and used it to forge an alliance no politician could ignore. That the disfavor was for contradictory reasons—the right because it feared the loss of traditional values and institutions, the left because it saw science and technology as weapons of those same institutions—was irrelevant in the battle for the irrational *geist* which dominated the country. All that mattered was that there was a common fear that could unite it and politicians who recognized opportunity when they saw it.

If the situation had remained in the hands of extremists it might have gone no further, but throw in the semi-educated middle that knew only what it saw on its television screens and you had a juggernaut. For a half a century that middle had been inundated with stories on nuclear armageddon, carcinogens, acid rain, the ozone layer, global warming, accidents, disaster, toxic wastes, radioactivity, destruction of the rain forests, Jeremy Rifken, Ralph Nader, et-cetera, ad nauseum, and ad infinitum, until the message had penetrated even the thickest of skulls. The Green Revolution had finally taken America, as it had Europe a decade earlier. Its philosophy, for all those who'd been asleep for the last thirty years, was We're playing God with Nature, and see what's happening to the Good Earth.

Still, the Greens might have remained only one of a number of powerful political coalitions in pluralistic America if it hadn't been for the new AIDS strain. And even that might not have done the damage it did if not for the

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overwhelming evidence that the new strain was an accidental release from a genetics engineering laboratory. Dan still shook his head whenever he reviewed the contents of the congressional report on the epidemic; it was of the few times where the networks hadn't had to resort to distortions for a good horror story. As for the Greens, they were having a field day with the news. Genetic engineering had been one of their top targets from the beginning, and they had burst out in full chorus for its complete abolition the moment the story broke, a chorus which had gathered voices by the hour until, by now, it had become a deafening roar.

The end of genetics research in the West was inevitable now. It was hopeless to argue, as one desperate professor had done so with Dan, that it was the Greens's contradictory, hamstringing, obstructive regulations that had probably caused the accident by making good, common sense safe science virtually impossible. Perhaps the good professor was even right but one might as well attempt to stop stampeding cattle with a treatise on elementary logic.

Still, Dan had held some hope. It was not until he learned that it was Toombs and Billings who were co-sponsoring the bill that he accepted how delusionary those hopes were. Even so, *he* would campaign against it. Of that there could be no doubt. They could kill Helene but they couldn't make him kiss their collective rings in gratitude, too.

More delusions.

Eric Lejune's apartment was small and tidy, like the man who occupied it. It was a paradox that the head of the multi-billion dollar funding machine known as the National Science Foundation was physically of such diminutive stature that you had to resist the temptation to address him in a condescending manner. The paradox was explained by an astonishing intellect which was just as skillful in the political arenas of the country as it was in the scientific ones. Lejune was disrespected only by those who did not know him, and of influential people they were few. Even the Greens regarded him highly, if through fear rather than admiration.

Of course the man could never have succeeded in pure politics. If Dan had occasionally resented the intellectual differences between them he'd also been thankful for the physical ones. Eric Lejune must have been born with that beaklike nose and a posture which made him a natural model for a gargoyle. And Dan could not remember a time ever when Lejune's hairline hadn't been drawn neatly across the crown of his head, not even during their days as undergraduates at Stanford.

The handshake was firm and warm enough. "I'm glad you could make it Dan," he welcomed the senator. "We haven't got a lot of time to work out our strategy." Taking Dan's coat he motioned to a comfortable chair in the living room and quickly rejoined his guest with a pair of teacups. Dan accepted coffee, knowing Lejune, who never drank the stuff, had gone out of his way to make it available. "I'm afraid it's instant," an impish smile apologized.

"I'm sorry to tell you this, Eric." Dan shut his eyes momentarily and wished he were anywhere but here, saying anything except what he was about

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to say. But there was no point in dragging it out. "I'm going to vote for the bill. I'm even going to be one of the ones grilling Johanson about the accident."

He had expected—what? He'd never seen Lejune appear shocked or angered, or as though he'd been caught unprepared in anyway for that matter. Certainly there had to be a first, however . . .

"Of course you are. Cream?" Was there even the tiniest stir in the man's face, the most ephemeral of spasms, as he prepared his tea? If there was Dan didn't catch it. "I take it they offered you support for more NASA projects if you cooperated?"

That's a polite way to put it. Dan thought sarcastically, nodded.

"You'd be a fool not to accept that," Lejune continued. "From what I read the Texas economy, not to mention your next campaign, could use the boost. Besides, you can't stop the bill anyway. You wouldn't even stop a veto override, not that there'll be any veto to override—the pres isn't that stupid. Did they *mention any projects specifically*?"

Dan never stopped being impressed with the way Lejune managed to dispose of the irrelevancies of a political situation and find whatever maneuvering ground his enemies might have overlooked. The bill was unstoppable, ergo it was a waste of time even thinking about stopping it. Dan was impressed all right—and disturbed. Political expediency was all well and good, but wasn't there any fire in the man's belly? Was he all molding powder and jello? For God's sake the country needed leadership in a crisis like this, not accommodation!

Look who's talking, a voice stabbed at him from inside.

"We agreed on funding the Mars project. They're all pretty excited by the thought of a manned expedition."

"National pride," Lejune snorted. "They'll support that anyway. Anything else? How about the colony projects?" Lejune's eyes sparkled when he asked that. He'd been high on the idea of either lunar and/or orbital colonies for decades. Dan understood why; serious scientific work in space required a permanent, stable human presence. Problem was, that serious science part was precisely what made it indigestible to the Greens, who feared more calamities should human beings start messing around with the natural order up in the heavens.

"I've been reluctant to bring that up," he explained to the waiting scientist. "They might object and . . . after all, they don't need me to pass the bill. I'm hoping to use more general promises of support to wrangle it out of them later. Especially if the Mars project goes over well; then there'll be a lot of public support for more programs."

He could tell from the expression on his host's face that Lejune thought his explanation was BS. "No. That's not good enough Dan. Right now, they're so flushed with victory they'll give you just about anything you want. Wait until they realize what they're doing and they'll weasel out of it. They've won the battle. We've got to plan how to win the war. Promise them anything they want, but get firm commitments for colonies. We'll need them."

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The man's phraseology frightened Dan. What "plans" did he have in mind to "win the war" with? Was he just that desperate for any straw to grasp at? "I'm not sure that's a prudent course, Eric. I'm not exactly in a position to make demands on anything right now you know. Not with this AIDS business as hot as it is. I say wait until the issue dies down before we start pushing for things like colonies."

That was sound reasoning and sound political strategy but Lejune didn't look impressed. Dan understood. Seeing what little rationality there was left in the country getting swept away had to be hard on the scientist. Lejune felt a desperate need to do something now. It was not going to be easy to persuade him that patience was the best policy.

But persuade him Dan had to do. If Lejune were allowed to pursue this colony obsession of his it could cost them what little political leverage they still had over the Toombs-Billings coalition and the Greens. It was not going to be easy, though. Dan would have to break down the scientist's rationalizations and expose his real motives. The problem with that was debating Eric Lejune was like trying to climb a teflon mountain with greased hands; you were rarely offered anything to get a grip on and what you were offered slipped away and sent you sliding back to the bottom.

Lejune looked as though he were going to offer a rebuttal, but instead pursed his lips and changed the subject with an abruptness that startled Dan. "How about yourself, Dan? How are you holding out?"

Strange. Normally a string of platitudes and reassurances would have flowed from Dan's mouth without hesitation. He found the determination of a few moments ago sliding away from him. "Frankly, I'm not sure. Lately—it's getting pretty hard to keep going to the hospital. I'm beginning to realize that Helene's been gone for a long time now, only I haven't accepted it yet." Prodded by the query, the truth blurted out of him, surprising him with the force of its anger. "I wish they'd let her die and get it over with. Watching her like that only makes it harder."

Lejune raised an eyebrow high over that ubiquitous nose. "You think not having to deal with Helene would make it easier to support the bill?"

It was the casual boldness of the question which shocked Dan more than anything else. It left him with nothing but the naked truth. "Helene would still be alive and well today if we'd supported genetics research the way we should have. The Huntington's gene was found back in the eighties. If we'd followed up—" he closed his eyes tight and tried to imagine the future the way it was supposed to have been. "I feel like a piece of shit for supporting those people now."

Lejune nodded. "That's understandable. You'll still do it though."

"What choice do I have?" The callousness of the man was infuriating. For the first time Dan realized how much he disliked the little scientist. Eric Lejune had spent a lifetime weaseling, conniving, maneuvering and manipulating his way into power, using his brilliance and charm as weapons for his ambition. Now that he had a chance to get what he really coveted he didn't care who had to pay what price for it.

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He realized Lejune was studying him. The feeling made him distinctly uncomfortable.

He decided to force the subject back to the one he'd come here for. "I really don't think asking for funds for colonies is a prudent course of action right now. I had to promise to roast Johanson just to get any commitments for NASA at all. If I start pushing they're liable to tell me to go take a hike. Besides—don't misunderstand me, Eric, I realize we've eventually got to have a permanent manned presence in space, but you have to think in terms of what the public will support. A successful manned expedition to Mars will get people behind the space program."

The words didn't have the force he'd intended them to have though. Lejune's bringing up Helene had clouded his thoughts, had gotten him both depressed and angry at everyone and everything.

Lejune looked at him as though he'd said something foolish. "You mean like the Apollo program did back in the 1970s? Not that that's your main fallacy," he said before Dan could formulate a reply, "Which is that if the T-B folks won't give it to you now they might give it later. The truth is, if you don't get it now you probably never will; give them another decade like the last one and they'll have a lock on the country's mindset we'll never pick."

Dan started his rebuttal then realized he didn't have an effective one. What the scientist was saying was probably right. But so what? Plain truth was, he didn't really give much of a damn anymore. The country was going to hell in a handbasket whether he tried to do anything about it or not. The social/cultural/political forces people he and Lejune were up against were simply too great. The problem with Lejune was, he was too far deep in his neurotic-genius suit of armor to be able to see that.

Strange, that at a moment like this he should think of his wedding day. The image of Helene's face, glowing with the happiness of the most important day in her life, floated before him like a veil. Like a dream. Somehow that day didn't seem real anymore. He suddenly felt as though he'd known a life only of loneliness and misery and had only imagined Helene to deceive the emptiness. The feeling made him choke with grief and the tears reached his cheeks before he could stop them.

"Please. Excuse me." He could barely get the apology out without breaking up completely.

He shook off the closing sarcophagus of emotions and forced himself back to reality. This business with Helene had affected him badly enough, but if things like this were going to start happening he would quickly lose all his ability to do his job.

"Don't you know why colonies are so important?" Lejune's voice broke through the shell. "What crippled the space program back in the 1970s was the philosophy that we should be spending our resources solving problems down here, on Earth. Actually, that made some sense at the time. Only we didn't follow up on it. We *haven't* solved the problems down here. We haven't because we've been outlawing the tools we need to do it. The result is that the logic of the seventies has been turned on its head: now if we want to

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solve problems on Earth we *have* to spend resources in space. We have to do the work up there we can't do down here."

The words buzzed Dan and it was several moments before he understood what they were telling him. Several more before he believed it. So that was why Lejune was pushing the colony idea so hard. Dear God, had the man lost his reason? Crushing his remaining emotions Dan directed himself to the crisis. "So that's how you 'plan' to 'win' the war." " Words like "insanity" and "madness" came to mind but he knew better. He had to appear to be giving the idea serious consideration, so that Lejune would see himself how crazy it was. "Only what makes you think the Greens will let you do the work up there anymore than down here? As soon as they find out what you're up to they'll shut you down, and put as many of you in prison as they can."

But Lejune smiled at an argument he'd obviously expected. "Come on, Dan. How are they going to find out? It's expensive to get men and equipment into space. You can't send a team of EPA sniffers on a surprise inspection; everyone will know about it weeks in advance. And once we're self-sufficient—and that's the first thing we'll work on—what will they do even if they do find out? Especially once we start announcing things like a cure for cancer.

"OK, I know it's not risk free. The only risk-free progress I know of is no progress at all. Risk-free progress is what people have been screaming for down here for the last half century. Risk-free progress is why Helene is just a memory."

Fresh anger flared inside Dan at the mention of Helene. He realized why: the scientist was using her to confuse him and bully him into joining a conspiracy to violate the law, a conspiracy that would destroy his political career if his part in it ever became known. A conspiracy, moreover, that couldn't possibly work.

Or could it? Dan remembered the science fiction novels he used to read when he was a kid. Colonies revolting against oppressive and irrational Earth governments was a common theme. What was that guy's name—Heinlein?

But that was fiction. This was reality. He shook the confusion out of his head. "It won't work. You'll get caught. And when you do it'll give the Greens the leverage they need to clamp down on everything. No. The risk you're taking is too great."

The image of Helene in her wedding gown flitted through his thoughts again, smiling at him. *Damn it. That's not fair. I can't fight both of you.*

"You really think so? You're starting to sound like the Greens yourself," Lejune accused. "You not only want zero risk but you think the way to have it is to have zero action." His eyes narrowed, focusing in on their target. "That's not the Daniel Ruiz I used to know."

Dan knew what he wanted to say—that actions should entail reasonable risks for reasonable gains—but he had to get Lejune to see how ludicrous his scheme was himself. The best way to do that was to present more sensible and promising courses of action. Like the Mars expedition . . .

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. . . OK, so that hadn't worked. There had to be other ideas.

The only problem was, he couldn't think of any. Lejune was right, in another decade the hold the Greens would have would be so tight no one would dare stand up to them. Crazy as it sounded, the idea of performing illegal research on space colonies was the only idea Dan had heard that had any chance of changing the course of history. For that matter, it was the only idea he'd heard at all, crazy or not.

So why couldn't he bring himself to support Lejune? The scientist was right about that, too. There'd been a time when he wouldn't have hesitated to risk his political career for something like this. Watching the Greens grow from just another powerful interest group to what it was today had been unbearably painful for him, especially in the light of Helene's sickness. Now, he felt so, so hopeless . . . .

"You've got to help us, Dan," Lejune was imploring him. "You've got to push for the funds. Helene is dead; it's too late for her. But there are millions of lives we still can save. You've got to rejoin the living."

He found himself shaking his head. The man is using my weakness to break me, he realized. Only he didn't know what to do about it. "You make it sound so easy. It's not going to be easy." The words were empty echoes in the tiny apartment. *At least you didn't say it's impossible*. That had to mean he still held some hope.

"I realize that," Lejune said. "That's why you're going to have to find the strength of leadership you used to have. That's why you have to put Helene behind you and get on with life." He hesitated, mulling over the words he intended to say next.

"That's the real reason I asked you over here tonight."

The statement didn't register. "What?"

"I didn't ask you here just for a skull session, Dan," Lejune confessed, measuring his words. "Your powers of leadership have been slowly disintegrating these last few years. Everyone knows it, especially the T-B people who are using it to extract your support in return for things they are going to give you anyway. You used to be one of the most potent political forces on the Hill. You rescued NASA practically one-handed at a time when politicians were supposed to pretend space didn't exist. But all that changed when Helene got sick. You withered away with her, to the point where people pretty much figure you to be washed up by now.

"At this rate, in a few more years you will be washed up, too. I can't let that happen. The country needs what few leaders like you it has. If I could do it myself I would but—" he chuckled and pointed at himself—"this face doesn't exactly inspire your average citizen. Besides, everyone would know why I was interested in genetic engineering."

Lejune stopped there to pour himself some more tea, leaving Dan to chew on the words. Like his notes back in the taxi they seemed to hover in space before Dan, not quite able to assemble themselves into meaning. They couldn't mean what they sounded like. Or could they? If they didn't why couldn't he feel the conviction of the denial? *Why don't*

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I have the answer I always have? Finally he realized he was staring vacuously into space, but all he could think to do was clear his throat.

"I've known for some time that I had to get you to see what Helene was doing to you," Lejune continued after a careful sip. "But you never gave me the chance until tonight. The armor you had erected around yourself was impenetrable. I knew it had to break down sometime, though. When I found out you were going to support the bill I figured the time had come. When you walked in here tonight, the way you looked told me you were ready."

Dan shook his head. What the man was saying could not be real. "How did you know . . . ?" Dan was certain he hadn't breathed a word about supporting the bill to anybody; outside of his personal notes—no, the scientist couldn't be *that* resourceful. Or could he?

Lejune smiled. "I have many eyes and ears," he said. "A mouth doesn't have to say 'yes' for the word to be communicated. I knew weeks ago you were going to support that bill, even before you made the decision yourself. Anyone with his eyes open could see it."

The way Lejune said it, calmly, almost arrogantly sipping his tea, forced Dan to accept its truth. Have I really been that obvious? he asked himself. All along he'd been certain he was keeping his agony shielded from his enemies, that to them he was the same effectual leader he'd been before Helene became ill. Of course he'd known himself how fraudulent the charade was, but he'd confidently assumed nobody else knew.

But they had known. Now that he looked at it, he could see that clearly. There'd been a time when even older colleagues on the Hill showed him the kind of respect that every politician knew meant power. But that time was history; what he got now was the same pretense of regard you gave to voters during a campaign. Handshakes and smiles and casual promises which meant nothing. It was so obvious in fact, that he wondered why he couldn't see it until tonight.

"I also knew you'd resist my idea of illegal research on colonies," Lejune continued. "Actually, I didn't want to tell you about that. But I had to make you see that you weren't doing anything to fight the Greens. That was part of the armor too; if you can't lick 'em join 'em, then pretend that you haven't. By the way, this isn't just a wild idea I dreamed up because of the AIDS panic. We've been planning this out for years. It'll work, largely thanks to the secret research we've been doing down here. In a few years we'll be revealing some big discoveries that will blow the Greens out of the water. But we've got to get the colonies to make it work."

That revelation, on top of everything else, was nearly too much for Dan. "What secret research? How—"

"You really should give up coffee," Lejune grinned. "It's bad for your nerves."

Dan took a deep breath, closed his eyes, and counted to ten silently. Secret research. No; I can't deal with that, too. Not now. Later.

In the darkness against his eyelids a bright angelic face whispered encouragement. *The coffee*, a voice grabbed him. *He's put something in the coffee.*

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He laughed aloud at the stupidity of that kind of paranoia. No drug was necessary. Lejune was doing well enough with insight and skill. And you thought you were going to break him down, another voice mocked.

"Have you always been such a shameless manipulating bastard?" he asked.

Lejune shrugged pragmatically. "Everyone has his strengths. For what I'm trying to do, you have to use all of them." He grinned. "Even if it makes you seem heartless at times."

"It's an insane idea," Dan finally said it.

"The nuttiest I ever had," Lejune agreed. "What choice do we have? The way I see it, we've gotten to the point where any 'safe' course of action is the riskiest of all because it's *certain* to fail. The enemy has us out-numbered, outflanked, and out-maneuvered. The only sensible thing to do is surrender and hope for a nice cubbyhole in the EPA or the FDA. Personally, I can't see myself spending the rest of my years studying the effects of computer terminal radiation on juvenile mice and screaming for more regulations when the mice develop post-nasal drip. I was meant for better things than that."

Dan smiled. He'd heard the speech many times before, in several different versions. He'd never thought the scientist serious in its implications though.

He studied his hands. "I need time. To think. For healing."

"Don't you see. There isn't time for that." Lejune started to say more, stopped and shrugged his shoulders. "Well, I knew it wasn't going to be easy."

Just like that, the discussion was finished. Both men knew they had nothing more to say that might influence the other's future actions. Shaking hands, they parted company.

In the taxi, Dan reviewed again the words he'd prepared for the evening. Again, their transparency was obvious, but this time for a different reason. He blinked with shame at the excuses and evasions which constituted his alleged reasons for supporting the bill. Fortunately, Lejune had demolished them before he could even bring them up.

Compulsively, he erased the entire file, answering the warning prompt with "Yes damn it" (and with the proper response after it informed him he'd made an illegal entry) and started composing his thoughts for the new challenge that lay before him. Getting the Toombs-Billings crowd even to realize that they had Dan Ruiz to deal with again wouldn't be easy.

But the words wouldn't come. There was still too much confusion inside of him. Frustrated, he double-clicked the newsnet program and started scanning the day's *Post*. There were the usual horror stories on the environment, most of which he knew from associating with Eric Lejune to be rubbish, news of fresh Green victories on both sides of the Atlantic, a small article on the new Chinese space station, and a healthy assortment of "human interest" stories, third-world problems, political comings and goings, and the unpleasant side of life in a large metropolis. All was dominated by the AIDS epidemic, of course. Dan blanched at the numbers being reported by the Center for Disease Control in Atlanta, although he'd seen them many times before; already the new strain was taking more lives per year

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than lung cancer, and if the rate of increase continued . . .

A small article on page two caught his attention. He skipped the background detail, having already read more than his fill about the trashing of Berkeley's biological laboratories, the beating of a professor and several graduate students which resulted in one of the students' death. "In dismissing all charges against the NatureFirst organization and the members who were involved in the raid," he read in shocked disbelief, "Judge Aaronson ruled that 'Given the powers of modern science and technology to endanger lives on a unprecedented scale, the acts of the accused must be considered as legitimate self-defense.' " The article went on to deliver more of Judge Aaronson's legal erudition: " 'To demand that a line of research be proven dangerous in advance places an unjustifiable burden on citizens who are attempting to protect themselves and their families. This court cannot, in good conscience, place such a burden.' "

Controlling himself, Dan carefully flicked off the program and stared at the now lifeless screen. No, it was not déja vù: he really had read the exact same story this very morning in the *Times*. Had read it almost word for word; it simply hadn't meant anything to him at the time. Hadn't meant anything because he was too consumed with his grief. Lejune was right. Finally he closed his eyes and listened to the sounds of the city streaming past the taxi. "Jesus," he finally whispered. "Jesus Christ."

"Hey! You all right back there?"

The voice made his heart jump. He opened his eyes to see the driver glancing at him in the rearview mirror with obvious concern.

"I'm OK," he answered. "Just tired is all. Been a long day."

And I'm just waking up.

The next day as he was leaving Helene's room he somehow took a wrong turn and found himself in the maternity section. Thoroughly lost he stopped at the nurse' station and asked for directions, directions which were delivered with more than generous portions of flirting.

Inevitably, as were all unwary passersby, he too was snared by the windows of the nursery. Maneuvering among the line of parents and grandparents he watched the tiny bodies as they struggled with the new world. Most slept peacefully but there was enough red-faced squalling to give him optimism for the human race. What astonished him the most though was that despite their apparent helplessness there was not a tube or a bag in the room. *Rhythms of life*. He'd almost forgotten that more than death happens in hospitals.

He thought of the children he and Helene would have had, if not for a faulty gene. That was a mistake, he realized. Sensing eyes on him, another voice countered *it's not too late*.

It was a crazy idea all right. But it was the only one that could work.

"Excuse me," he returned to the station, "Could you direct me to the nearest pay phone? Thank you."

The scientist's answering machine announced that he was out at the moment and could you please leave a message at the tone.

"Welcome me back to the living," he said. ■

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The Alternate View

SKUNK WORKS

G. Harry Stine

Today's world appears to be ruled by Cheops' Law: "Nothing *ever* gets built on schedule or within budget." It seems that everything takes more time to do and costs more money when it's finished. "Budgets" have become at best "educated guesses" or usually WAGs (Wildly Assumed Guesses).

Example: During the 1960 decade, it took Americans only eight years and about $25 billion (depending on whose figures you use) to land men on the surface of the Moon and return them safely to Earth. Recently, NASA officials have stated publicly that they couldn't get men to the Moon and back in the remaining years of this century and that it would cost at least $100 million, probably more.

Yet history clearly shows that major technological breakthroughs have been made in a matter of months and on limited budgets.

To do this sort of thing requires the establishment of what has become known as a skunk works operation.

The term "skunk works" comes from an unsavory fictional factory having something to do with rendering or otherwise processing skunks for an unknown or unstated purpose. It was operated by the Scragg brothers in Al Capp's famous comic strip, "Li'l Abner." The Skunk Works sat off by itself on the top of a mountain and was so odoriferous that only the raunchy Scragg brothers would work there.

Over the past 30 years, "skunk works" has been applied facetiously to describe an engineering operation run by a strong leader with a limited number of workers operating with very loose procedures to attain a very difficult goal. The objective of a skunk works was to get a specific job done quickly and often in a clandestine manner. Never mind procurement regulations. Never mind contract hassles. If something was needed, it was purchased or built. No security walls or sacred turf existed within a skunk works. Anyone inside the walls could talk to any other skunk worker about anything. But no one talked about the work with anyone else outside the walls. The purpose was simple: Just get the damned job done!

This sounds like a paradise for any engineer or techie. But it's damned tough to set up. It's damned tough to run. And it's damned tough to work in a skunk works because there are no time clocks, no lunch breaks, no weekends, no paid holidays, and no rest for the weary.

Furthermore, a skunk works provides no guarantee of job security. When the project is completed, the skunk works is usually disbanded. Or it's reorganized and proceeds toward the next goal or another one. This feature was designed to prevent the NIH (Not Invented Here) factors as well as empire-building. Very few skunk works have succeeded in doing this. Like any organization, a skunk works attempts not only to grow

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but to survive.

Skunk works have a long and illustrious history. Nothing like them could exist before the scientists and the industrialists came to their concordance in about 1850. Before that time, scientists worked primarily for wealthy patrons. But when the Industrial Revolution began to accelerate its pace, it quickly became obvious that the rough-and-ready, rule-of-thumb, cut-and-try, uneducated engineers of the time didn't really have enough background in basic science. So the industrialists began supporting the work of scientists in both basic and applied research. The latter work was aimed at solving problems in industrial technology by discovering new methods. It was also used to come up with new or improved products.

The earliest example of a skunk works that I could find involved—you guessed it—the development of a weapon.

At the beginning of the Civil War in 1861, the Confederacy knew it couldn't match the Union navy ship for ship. The Confederate leaders also knew that the Union navy would quickly establish a blockade to prevent the secessionist states from trading with the rest of the world. So the Confederacy had to develop naval vessels of enormous power manned by small crews and practically impervious to cannon fire. In short, it needed ironclad steam-driven warships.

Therefore, the Confederacy adopted an idea that the Federal government had been kicking around and rejecting for more than 20 years. In fact, the United States government had started building such an ironclad warship in 1840. But Congress had authorized and cancelled appropriations as the political support for the project blew hot and cold. (Does this sound familiar?)

In 1861, at what is now the Norfolk Navy Yard, the Confederacy rebuilt the captured Union frigate the *Merrimack*. An armored iron hull was added, steam propulsion was fitted, and additional cannon were mounted. The ship was rechristened the *Virginia*.

The Union got wind of this development and began its own crash program. It called upon the expertise of a Swedish-born engineer, John Ericsson, who designed a radically new ironclad warship, the *Monitor*. The Union ship featured a single rotating gun turret mounting two 11-inch Dalhgren muzzle-loaders (breech-loaders were specified but weren't available in time). The *Monitor* sat very low in the water with only a foot or so of freeboard. It provided very little to shoot at. The keel was laid in the New York Navy Yard on October 12, 1861. The ship was launched 126 days later. She was ready for sea on February 15, 1862. The shakedown cruise was the voyage through rough seas to Hampton Roads, Virginia to confront the *Virginia* in the first famous battle of the ironclads which took place on March 9, 1862.

The *Monitor* had cost $275,000.

The next skunk works operation I could find in history perhaps wasn't a skunk works as we know it today. However, much of skunk works techniques, management philosophy, and operational methodology was established in the first industrial research laboratory which was opened in 1876 by Thomas Alva Edison in Menlo Park, New Jersey. Edison set out to create "inventions

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to order'' although the lab was originally tasked to do applied research in telegraphy. In this lab, Edison developed the first practical electric lamp, which he demonstrated on January 27, 1880. Edison was not the first to invent the electric lamp, but he was the first to develop a practical and economical one plus the total electrical system to support it. In 1900, Edison got together with financier John Pierpont Morgan to found General Electric Company, which opened its first industrial corporate research laboratory in 1909.

This established a trend of the in-house corporate skunk works, even though they weren't called that. E.I. DuPont de Nemours followed suit, especially when they received the bounty of the German chemical industry patents early in World War I. Bell Labs was also formed early in this century. So were the RCA labs, later called the David Sarnoff Laboratory. Many of these industrial research labs are still around and still functioning.

David Sarnoff was as important a player in skunk works development as John Ericsson or Thomas A. Edison. Sarnoff had the knack of knowing precisely when to cut off research, get the scientists away from the project, and go to production.

During World War II, skunk works everywhere produced a host of inventions and developments upon which much of our modern high-tech world depends. Early digital computer technology came from the Princeton Computer Laboratories. The British developed RDF (radio direction finding, later called ''radar'') in a skunk works atmosphere. The German Army certainly had a glorious skunk works going at Peenemunde to develop ballistic missiles. And, of course, the biggest and grandest of all skunk works was the Manhattan District of the US Army Corps of Engineers. In thirty months, the Manhattan District went from the first Staggs Field nuclear reactor to a working nuclear weapon at a cost of $4 billion.

But it took Clarence ''Kelly'' Johnson and Dr. Maxwell G. Hunter to bring the skunk works concept to its pinnacle of achievement.

The Lockheed U-2 spy plane was developed in a little more than a year by the first skunk works to use that name, a team of engineers led by Kelly Johnson in Lockheed's Advanced Development Projects office, *the* Skunk Works. The objective was to build a subsonic airplane that would fly higher than any interceptor aircraft or SAM could go for the purpose of over-flight reconnaissance of potential enemy nations. The U-2 was a jet-propelled sailplane. Its biggest shortcoming was its need for a sophisticated autopilot to keep it under control at very high altitudes, where its stalling speed and cruising speed were within a few percent of one another. The reason Gary Powers was shot down by a Soviet SAM near Sverdlovsk was the failure of the autopilot which forced him to descend to an altitude where the SAM got him.

The Skunk Works also developed the follow-on to the U-2, the Mach 3 A-12, which later became known as the SR-71 Blackbird. At this writing, the Blackbird is still the fastest known operational aircraft in the world. Again, the A-12 project was done quickly. In a technical paper Kelly Johnson wrote, ''I believe

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I can truly say that everything on the aircraft from rivets and fluids up through materials and power plants had to be invented from scratch." A high level of stealth technology was incorporated in the A-12. This aircraft went from project approval to first flight in 26 months. No figures on the cost of the A-12 program seem to be available. However, Congress turned down a proposal for the F-12 interceptor version because each would have cost $25 million. (Compare this to present-day cost of an F-15 or a B-2.)

At about the same time that Kelly Johnson was developing the U-2 and A-12, Dr. Maxwell G. Hunter was developing the Douglas Thor IRBM for the United States Air Force. This complex project was completed in thirty months with less than a thousand engineers. Today, the Thor's direct descendants have become the medium-lift expendable workhorses of the American space program, and it takes more money and more people to launch a Thor-derived Delta than when Hunter started from scratch 30 years ago.

A true skunk works operation is quite clandestine these days. But we get occasional snippets of information that indicate Lockheed is still at it in the Skunk Works. The existence of the F-117A stealth "fighter" was known years before the first poor photo of it was released by the Air Force. And there are rumors of something called "Aurora" whose mission and performance we can only guess at.

All of which goes to prove that we can do anything we want to do if we do it without huge organizations and bureaucracies, and if we have a clear objective when we start. It also indicates that we'll probably never do anything that requires thousands of people, billions of dollars, and a decade before we begin to see results. Cheops' Law is real. ■

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Migrating to the future can be a tempting option, but your situation when you get there will be very dependent on what positions are available. Which may not be at all what you had in mind. . . .

F. Alexander Brejcha

THE NEW LAND

Laura Lakey

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At the top of a high cliff overlooking a surging ocean, an antiseptic city sprawled. It was sparkling, almost unnaturally clean, thanks to the tireless efforts of an army of tiny machines. A long, straight, central boulevard cut it in half. On each side of the dividing road, a line of gleaming silky metal domes was strung. They lay like two parallel strands of giant pearls, half-buried in immaculate grass. And at one end of the avenue stood a six-story tower, the only structure with windows thrown open to admit the fresh scent of newly mown grass. A startling smell in the alien setting.

A jungle stirred around the city. It seemed to be kept at bay by the tower, but was actually kept back from the sparkling buildings by invisible barriers that kept the swaying growth from invading the lush and perfect lawns surrounding the domes. Tall trees, eerie, with elongated and twisted trunks only kept aloft by the light gravity of the newly built world. A myriad of slender creatures flitted through the rich and gently sighing undergrowth.

But at the barrier, slitted yellow eyes watched the city warily.

Light. Brilliant, burning light stabbed into her brain! *I can't breathe,* the panicked thought flickered. Words? The brain tried to forge unfamiliar links. Speech. A croak. She tried again. This time sound emerged. "Where . . . am . . . I?" The world spun and flickered. Unfamiliar sensations . . . sound. Her own voice? But it was too much to handle and the room spun as darkness reclaimed her.

* * *

On the other side of a large one-way mirror, two men stood in the darkened monitor room and watched the still body on the revival stand.

"Well?" Jim Martin was afraid to consider what failure might mean.

"Just a minute!" Sayers snapped. "She's blacked out again. It's tricky. She was frozen much longer than the others, and there may have been damage. People can't be cryogenically suspended forever, you know. There are limits. I can't promise you won't get a perfectly preserved chunk of meat."

Martin cringed. "I'm afraid that won't help. We need her knowledge. We can't afford to wait twelve years for an answer from Earth. We were lucky to have an anthropologist like Dr. Nathanson among the freeper inventory."

"And lucky that she was one of the first to be properly frozen." Sayers checked his bio-monitor panels critically. Then his expression changed. "But her body is in prime shape, definitely in prime shape!" He craned his neck to look at the draped form of the newly revived frozen sleeper. "Even by today's standards."

Jim frowned. "Why don't you give her a chance to wake up before you go assaulting her! She's hardly in a position to defend herself!"

A soft moan interrupted them.

Gradually she was aware of the room around her again, a dim memory of waking up before teasing her mind. It was cold. A smooth pastel-yellow sheet was draped over her. She was naked under the sheet, she realized, and glanced

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around nervously. Soft pearly light flooded the metallic walls of the small square room. Beyond her bed, it was almost empty. The only exceptions were a large mirror on one wall and a covered, coffin-sized tank of milky fluid that was next to the bed she lay on. A hoist arrangement hovered over the liquid. Was she going to be put into it? Or had she been pulled out of it?

And there was another question to be answered. "Where the bloody hell am I?" Her voice was a hoarse croak as she looked around. She felt incredibly lightheaded, but she was also curious. She clutched the sheet around her and started to get up when a door opened in the one wall. Two men entered the room. One was tall, over six foot, and powerfully built. He had neatly combed ash-blonde hair and a craggy, interesting face. He wore a tight blue jumpsuit that revealed his muscular body quite nicely. All of a sudden, she felt terribly self-conscious.

The other man was short and soft-looking with black hair, and a face as nondescript as the rest of him. His brown tunic looked a little rumpled, except for around the waist. And the way he looked at her was suddenly familiar. She just had not seen the look for a while. Then she caught a glimpse of her reflection and gasped.

A young woman she had not seen in the mirror for decades was staring back at her, open-mouthed.

She gathered the sheet around her carefully and started to get off the table, eyes locked on the startling vision. Suddenly she found herself falling, slowly, to the floor, the sheet dropping clear. Both men rushed towards her gracefully but she held up a hand sharply. "No! I'm OK." She wrapped the sheet around her again and got to her feet gingerly, her face burning as she almost fell over again. Standing shakily, she gritted her teeth in determination and tentatively jumped up and down a little in place, realizing that the gravity was much lower than it should be. She wasn't on Earth anymore! Giddily, she took it in stride, the cumulative surprises numbing her a bit.

She started over to the mirror in awkward bouncing steps. No wonder the men had moved so gracefully; it was like walking underwater. They were obviously used to it. Then she was facing the mirror. She looked at it nervously, afraid that it should turn out to be a window instead. One hand crept up to touch her cheek, feeling the satiny softness of youth, not the cracked and leathery skin that had developed over years of roughing it in the wild. And as she touched her hair, she felt the long rich black tresses of her youth instead of the dried grey strands she had grown accustomed to.

In the mirror, the young woman touched a cheek, too, and stroked her hair in wonder.

She turned to the men, her eyes moist with tears. "What's going on? That's the way I looked when I was in my twenties! But I'm over fifty, and pretty weathered by now." She laughed, a brittle sound in the bare room. "And where the bloody hell am I?" Again, the conditioned British curse slipped from her lips, a vestige of a one-year assignment with an English expedition to Central Africa.

The tall man came over and offered

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a robe he had pulled out from somewhere. "Here, Dr. Nathanson, put this on," he glanced sharply at the shorter man, "we'll leave you until you call us. Then I'll answer some of your questions."

"No! Don't leave, please." She didn't want to be left alone. "Just turn around . . . Ah, hell. You saw me before, I'm sure," she realized, remembering how she had awakened. Moving quickly, and feeling the shorter man's eyes burning on her, she dropped the sheet and slipped on the robe. As she did, she glimpsed her firm, young woman's body and her head started swimming with questions. After a moment, she clinched the belt around the waist of the soft emerald-green robe. Her hands stroked it briefly in wonder; it felt like velvet, but thinner.

As she wrapped herself up and stepped into the soft brown slippers the tall man handed her, she watched him carefully. "What's your name?" she asked, intrigued by his sensitive blue eyes and strong face.

"Jim Martin, I'm the colony director. And this is Mike Sayers, one of our freeper-uppers-bio-nanotechnologists," Sayers grinned toothily. "He's responsible for reviving our freepers, frozen sleepers." Martin grimaced as he kept correcting himself, obviously used to conventions that would be unfamiliar to her. "The cryogenically frozen colonists we brought along."

Her eyes widened. *Colonists? Brought along where?* she wondered. But there were so many questions jumbling that she wasn't sure where to start. *For another thing, what is a bio-nanotechnologist?*

Martin must have misunderstood her expression because he smiled warmly. "Trying to place my age?" he asked jokingly, his voice deep and resonant. "Biologically I'm over a hundred. And if you count the time I skipped on the way out here because of time dilation, I'm even older." She stared. "And I'll look like this for a few more centuries. Just like you will. Although, fortunately, you'll look like you, not like me." He grinned.

His words echoed in her mind. "How . . . I don't—"

"Did you ever hear of nanotechnology?"

There was that word again. Then, her mind flashed back, the words teasingly familiar. Slowly, a recollection: "Something about microscopic machines that can duplicate themselves and alter matter on the atomic level, isn't it? I remember that there were some items in the news in the late nineties, around . . ." she choked, "around the time I was diagnosed as terminal, that talked about some trial programs using it for computers and synthesizing rare compounds."

Martin's face darkened. "It went a lot further." Then he forced himself to smile. "I'll explain some of what happened later, but for right now, let me just explain that one of the ways nanotechnology was applied was in constructing miniature machines to clean up and repair the body—"

"Curing my cancer?"

"And more. Like I said, we live for centuries now, bodies constantly kept in top shape by housekeeping machines called nanorooters." She smiled at the term. "And naturally, in healing you,

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your body was restored to its optimum."

"And I'll stay like this?"

"For a long time."

She glanced back at the mirror and marveled. Then the giddy sense of unreality evaporated. "What's the catch? And where am I?" She felt too heavy to be on the Moon, but could she be on Mars? They had been talking about a colony project there, she knew, back in . . . "And what year is this?" Suddenly she was desperate to find out how long she had been asleep.

"2175."

She stared, the number echoing in her mind as she figured it out. Almost 180 years! She had been frozen in '97. 1997! She grabbed for the table. Martin was at her side immediately and with an easy thrust grabbed her by the waist and lifted her up to sit on the table, iron fingers gentle. Behind him she saw Sayers watching them darkly.

"Sorry, that must be a bit of a shock," Martin offered. "I forget that those numbers must have a little different meaning to you—"

"Considering I only expected to live a few more months, and even if I wouldn't have developed cancer, I still would only have lived another thirty or so years." Her voice was shaky. "Look . . . Jim?" He nodded. "Call me Julie. Go easy, OK? But I want to know what the hell I've missed! And why don't you start with where we are."

"StarStep. It's a small planet about the size of Mars that revolves around Barnard's Star, about six light-years from Earth." Julie's eyes widened and her fingers gripped the edge of the table with finger-whitening intensity. "It was a dead chunk of rock until about eighty-five years ago. Then a series of remote packages loaded with nanomachines, we call them nanosheens, started landing on it and changing it over the course of a few decades. When it was ready for it, it was stocked with life and has been slowly evolving since. That took decades more, of course, but eventually it was ready. Some nanosheens have to stay active to keep the air dense enough to breathe since the gravity is so low. And keeping other gases and moisture in is also a problem, but again, certain strains of nanomachines will stay active to compensate. But otherwise, StarStep is totally self-contained now. We just got here a few years ago ourselves. . . ." He stopped, seeing her dazed look.

"Building a world from scratch?" She was staring at him. "My god! And if you could do that . . . was the Earth cleaned up, too?"

His face twitched, a pained look on it. "Yes. It was. After it was almost destroyed."

She didn't pry. She'd ask more questions later. Obviously it was a sore point. But it brought up another question. "OK, you rebuilt this world and you're colonizing it. But why am I here? And why didn't anyone ask me if I wanted to come?" Her mouth tightened into a slash.

"They all ask that, don't they?" Sayers cut in. "Well, I'll leave you to explain. I've got work to do. I'll tell your wife where you are in case she's looking for you." He gave them an evil look as he sidled out the door.

Julie flushed hotly, forgetting her question to Jim for the moment. She hadn't realized how she had been re-

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acting to Martin until Sayers's comment had brought it home. It had been so long. And now she found out that he was married. That figured. She remembered living briefly on the West Coast, in San Francisco. Her one friend had cautioned her not to move there: "The men are married or gay, and the cute ones are gay." But Martin didn't even seem to notice Sayers's comment. Either he was so happily married it hadn't even entered his mind that she might find him interesting, or he was so callous he didn't care. Or, he was gay. But somehow she couldn't believe that. She studied his face and decided the first guess was probably the right one. She didn't know why, it just seemed that way.

"Your wife?" she teased, curious. His face lit up. *Yup, happily married.*

"Yes." He pulled out a flat disk from under his tunic proudly and she saw a stunning three-dimensional portrait of a strangely beautiful woman. She looked like an El Greco painting, impossibly slender and almost elongated. Martin saw her surprise. "She's a Lunie, from the Moon. Under the lower gravity, people grow much taller, and look a little different." He grinned. "I only come up to here on her." He placed his hand around his Adam's apple. "She's gotten to be quite a fan of yours since reading about you. She wants to meet you since we're reviving you early. And she's not alone."

"What do you mean 'reviving me early'?"

"We're reviving all the freepers in batches." (*All what freepers?* she wondered.) "Giving each group time to get oriented and situated, and you weren't scheduled for another year," he explained. He saw her open her mouth as she remembered what she had started to ask, and cut her off. "I know you have a lot of questions, including the one I haven't answered yet, but I'll get to it in a moment, I promise. I better explain a little background first." He looked around, frowning. "I think we can find better surroundings though." He looked up. "Star?"

"Yes, Jim?" A rich, cultured voice seemed to echo from all around. Julie looked around, confused, trying to find its source.

"Locate Serena for me, please."

"Dr. Andrews is in the control-room viewing the tribe." There was not even an instant's hesitation in the reply. "They appear to be holding a ritual sacrifice. Most interesting. The leader is just about to slit the throat of—"

"Fine! Let her know that we are on the way up, please." Jim looked uncomfortable.

"Sacrifice? Blood sacrifice? What tribe?" The words tumbled out in a rush as Julie's confusion grew. "I thought this was a dead world until you built it. Who is holding a blood sacrifice?"

"It's a little complicated," Jim started to explain. "There was an unforeseen development—"

"Obviously!"

"There were a lot of life-forms introduced. An attempt at building a balanced ecology. Not as varied as Earth's, of course, but still quite rich. A number of different predators were also introduced. Some of these, for the temperate zones, were genetically engineered North American Cougars. Well, apparently there was an accident. A number of the specimens experienced brief premature

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thawing because of a malfunction. It caused some minute genetic "damage." Change is more like it. It was a one in a billion accident—"

"What happened?"

"The damage, combined with the genetic coding for adaptability as well as temporary rapid evolution and breeding, resulted in a considerable increase in intelligence," he finished.

"And by the time you got here they had developed a tribal society complete with ritual sacrifices?" She was staring at him. "My God, in how long?"

"Forty years, roughly, for the Cougars. Remember, they were altered to mature rapidly and to be prolific. The encoding is breaking down now, so they are reverting to more normal life-spans and breeding cycles. But for the first thirty-some years they were producing a new generation every four months, with a gestation period of about six weeks."

"They must be bloody geniuses!" Julie was pacing up and down rapidly, a strangely floating step. She was surprised how quickly her muscles were adapting to the new gravity. Of course, she had always been quick to adapt to new situations. She considered what Jim was telling her, beginning to understand why she was suddenly of interest. But she realized something frightening. There were some examples of accelerated cultural developments that would be relevant here, and she couldn't think of them! She tried to remember other literature and experiences and found herself unable to pin anything down. She had spent time in Africa, she knew that. She remembered burning sun and freezing nights, vague impressions of going for days without eating or sleeping, but when she tried to remember facts, she kept drawing blanks.

She turned to Jim, frustrated tears flooding her eyes helplessly. "I can't remember!"

"What?" Jim looked confused.

"Anything!" It was almost a wail. Suddenly she was terrified. "I remember who I am, and I know what I am, and some things about what I've done. . . . but I can't remember my papers. I must have written some, you said so. And I can't remember the specifics of my field work. Some flashes, yes, but only generalities."

"Star! Analysis!" Jim's command to the ceiling was terse.

Who was he talking to? she wondered again.

"Insufficient data to make a diagnosis, but suspect physiological brain damage due to suspension. Testing needed to determine extent and nature."

"Call Dr. Gratch and tell him we're on the way to the Med-Block."

"Shall I also inform Dr. Andrews?" the cultured voice inquired.

"Yes."

Julie had had enough as Jim indicated the door, trying to usher her out, and she stopped. "Whose is that voice?"

Martin looked embarrassed. "I'm sorry, I should have introduced you. He's Star, my wife's pet project. He is probably the most sophisticated computer in existence. Thanks to nanotechnology, he fits the complexity of a human brain, nearly, into a one-meter cube—"

"Nearly? I would like to see the human brain simultaneously calculate—"

"Remember our talk about interrupt-

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ing people, Star?'' Jim cut Star off with a grin as the computer indignantly reacted to Jim's qualification.

''I'm sorry,'' Star responded, actually managing to sound contrite.

''My wife's latest work. She is working on emotion-simulation. A major project, to get his reactions situationally appropriate. But I swear she's done too good a job sometimes. I honestly think he feels those things.''

Star's reaction was immediate. ''`I think, therefore I am.' was a comment made some time ago by one of your philosophers. Would not `I react, therefore I feel,' be equally appropriate? When you can't tell the difference between the simulation and the real thing, is there a difference?''

Jim and Julie stared at each other somberly. After a moment, Julie's mouth twitched and she licked a forefinger and drew an imaginary line in the air. ''That's one.'' She grinned and looked up. ''Nice to meet you Star. If only you had a body to match that mind and voice!''

''I do. Smooth and strong.'' After a moment of silence during which Julie clenched her mouth tightly shut, he went on a little petulantly. ''That was a joke. Dr. Andrews is expanding my programming.''

''I know,'' Jim muttered. ''I've got to talk to Reena and make sure she doesn't go too far in that direction!''

The sun was directly overhead and the time was near.

Around the tribe, the tall and impossibly slender trees stood silent, anticipating. A gentle rain had been falling until just a little while earlier and heavy mist still hung in the air, suspended by the low gravity. A warm rainbow colored the air, its message clear. It was time.

At the center of the clearing, the warriors waited. Thirty slender feline figures standing facing each other in two proud rows of gleaming white muzzles and gracefully curved tails. Their patterned fur glistened with moisture, a symphony of various brown shades ranging from almost-yellow to near-black. They were naked except for crude leather belts from which skin pouches hung.

A tall figure dominated the meadow at the head of the columns of warriors, a tightly woven necklace of vines hanging around his neck. His coat was a little darker than the others, the whites of his muzzle and belly a brilliant contrast to the rest of him. His tail lashed back and forth in agitation, betraying an inner tension his impassive face denied. At his feet the battered form of a wounded female warrior crouched, head held proudly high, even as pain etched her face. Two of her legs were bent at impossible angles, a splinter of bone protruding through the skin of her left hind leg. Coagulated blood matted her fur and a cloud of hungry insects hovered over her, landing to feed on any fresh blood seeping out.

Thirty throats growled the ritual song of sacrifice, and the tall figure pulled out a chipped slate dagger from his belt.

Speaker held the Claw of Power over Ringed-Tail's throat. Her sacrifice was needed to give them strength for the battle against the sky-creatures. But it would not be enough. The blood of one of the creatures was needed to give true

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power over the invaders. But Ringed-Tail had proven her strength against them, so her sacrifice would give them all strength and free the Group from caring for her. But for some reason, it was difficult for him.

Speaker was confused. It was law to destroy those who could not hunt their own food and truth that the blood of a victor gave strength to those who drank it. And he knew she gave her life proudly, to die with honor. So why did his paw tremble? Hesitate? Ringed-Tail was of his birth-group and she had been his hunting partner and mate. Her last birthing had been good with four healthy younglings, two of them needed females. But why should all that suddenly come to mind?

As the growling chorus reached its roaring climax and cut off, the sudden ringing silence triggered Speaker's arm out of habit.

The rough blade descended in a sweeping slash that ripped open the freely offered throat. Blood flowed fast into the painstakingly shaped hollow bowl on the sacrifice rock.

One by one, the members of the Group filed past and lapped of the rich steaming fluid. Then each sank their fangs deeply into the exposed throat of their life-less fellow warrior to taste Ringed-Tail's flesh as well as blood. Not to eat, only taste. That way she would join the Forebearers in honor, not be trapped with the spirits of their victims.

But when it was his turn, the warm blood twisted his stomach as spoiled meat does, and as he sunk his teeth into Ringed-Tail's throat the image of their last mating flashed into his mind and he felt like a youngling swatted across the ground for getting his lesson wrong.

But the others did not notice, and with the ritual complete, the body was efficiently sliced up and distributed to the younglings for food. Perhaps they, too, would gain some strength even if no ritual was observed. But Speaker could not watch, for some reason.

As they entered the administration tower's comfortable lounge Julie sighed in relief. Real honest to goodness daylight and fresh air enveloped her. Soft red carpet swallowed her feet hungrily and rich wood-paneling covered sections of the walls, alternating either with wide windows, or more of the same satiny metal that had made up the walls of the room she had awakened in.

Beyond the open windows, familiar green colors called to her. She responded, heading for the windows until she saw who was waiting for them.

She looked up at Serena enviously. There was no mistaking the computer programmer. Julie could understand Martin's loyalty. Once she got used to the strange slimness, and height, she realized that Serena was probably one of the most beautiful women she had ever seen. Her close-cropped ebony hair was gracefully styled to accent the cheek-bones and delicately arcing eyebrows, and her eyes were an eerie pale blue that was almost silver. And she wore a smile that was as instantly welcoming as her warm embrace.

As an exercise in contrasts, a distinguished-looking black man, with an equally noble belly, stood next to Serena. He looked remarkably light on his feet considering his proportions.

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"Jim, boy," he nodded towards Julie respectfully. "Aren't you going to introduce us? I've been dying to meet this lady, even if I must confess that anthropology is not my specialty—"

"Neither is it mine, anymore, it seems." Julie cut him off bitterly as she spun and looked out the window for her first look at StarStep. She put her hands on the cool metal of the window-ledge and breathed in the fresh air that came through the open window of the lounge where Jim had brought her after being examined by Dr. Gratch. Outside, strange ethereally slender trees swayed gently in the breeze, looking as if they ought to be falling down. The startlingly familiar fresh scent of newly mown grass filled the air and she breathed it in gratefully. A welcome element of normality in her suddenly disordered world.

"What the blazes does she mean?" She heard the black man's upset question to Jim.

She turned reluctantly and stopped him from answering. "It means that apparently I was suspended for too long. That, and the technique used on me wasn't quite refined enough yet." She sat back on the window sill, feeling the cool ledge through the thin blue tunic she had been given by Dr. Gratch after the examination. "How did the good doctor put it?" She cocked her head back, studying the ceiling.

Her voice took on a pedantic, vaguely foreign tone. "Sensory register, short-term and long-term memory capacities are unaffected, and her intelligence level remains at above average to gifted. Early memories are relatively unaffected, but later memories, particularly left-brain memories, are severely damaged. However, from what we can determine, emotional, spatial and sensory right-brain memories are almost all intact." She dropped her face and met the concerned questioner's gaze. "My name is Julie Nathanson, formerly Dr. Juliet Nathanson, world-renowned anthropologist, but presently lost, hopelessly unqualified for anything and beholden to the kindness of strangers. Call me Julie. And who may you be, sir?" She swallowed and forced down the sinking feeling in her stomach.

"Ken Miller, Dr. Ken Miller if you want to be pedantic about it. Panda," he sighed mournfully, "if you are an irreverent former, or even present, student. Apparently some seem to find that the combination of my shape," he patted his belly fondly, "complexion—a gift from my ancestors—distinguished hair and my choice of stylish attire, all add up to give me the resemblance of that noble oriental animal. If you are interested, as alas too few are, my specialties lie in astrophysics, physics, a number of intriguing and esoteric realms of math, and the lost art of Southern cooking. You can call me anytime, and call me Ken." He gave her a wide disarming smile, teeth brilliant against his ebony skin, and bowed formally.

She couldn't help it but giggled. God help her, like a school girl. But for the first time since she had awakened, she felt human and totally relaxed. She grinned and curtsied. *Where the hell had she learned that?* "Good sir, are you trying to charm me?"

"Egad! She's on to me. Indeed I am."

She eyed him speculatively. No longer really seeing the belly, but looking into

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his eyes. Behind the cheerful smile and disarming manner, she saw real, genuine concern and looking more serious, she approached him and kissed him gently on the cheek. "Thank you. I needed a little distraction. All this," she waved her hand vaguely around and aimed it out the window, "is a bit much to take, all at once. Even if I would have retained all my faculties—"

"Dr. Nathanson," Miller interrupted gently, "your faculties, and I have the impression they are considerable, are unimpaired. Only your memories are a bit foggy."

"I stand corrected."

"Good, because I refuse to believe that everything is lost. We have all your papers in our library I am sure—"

"I am second to none in my selection of reference material." A proud voice cut in from above.

"Star, shut up!" Miller shook his head and glanced over at Serena. "My dear, he's getting positively conceited. Please fine-tune his programming a little so he doesn't interrupt people." Serena blushed as Miller turned back to Julie.

"As I was saying before I was so rudely interrupted," he glanced up at the ceiling with a frown, "we have your work on file and if you study it, maybe it'll jog your memory a bit."

"Yes," Jim broke in, "we have a problem."

"The cats!" Julie flushed, embarrassed that she had forgotten. Her eyes widened and she turned to Serena. "Just what were they doing? Did you record it?"

Serena started to speak until Star stopped her. "Replaying on main monitor."

A large portion of a blank wall suddenly shimmered and Julie gasped as she found herself looking at a three-dimensional scene, as if it were right on the other side of the wall; *in place of the wall,* she corrected herself.

"The monitors that recorded these were roving eyes and are no longer in place, I'm afraid," Star supplied. "The images are a bit fuzzy because of the heavy moisture content of the air at the time of recording, and the distance at which the roving eyes were positioned. The Cougars have an extremely developed olfactory sense and would have detected the monitoring at closer range."

She thanked him absently and watched the bloody sacrifice play itself out, and the subsequent feeding. And as the last of the victim's body was ripped apart by the hungry cubs, she tentatively asked Star if he could replay parts of the recording and zoom in on certain sections. Subconsciously she was already thinking of the computer as a person. Star obliged instantly. Julie leaned forward intently as the images flashed on the screen. She especially wanted to get a closer look at the sacrifice, and the injuries that were obviously crippling it.

When she was satisfied, she glanced over at Jim. "Have you had any interactions with these . . . people? Specifically, have any of them attacked you and gotten away with it?"

"You are blasted right," a new voice interrupted, tinged with an unmistakable accent. She turned to see a short stocky man with red hair standing in the open doorway. Beyond him, she saw a number of other people crowding close.

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Jim sighed. "Dan, come in, and the rest of you, too," he raised his voice. The newcomers all filed into the lounge.

"Julie, this is Daniv Tsielkovsky, one of the freeper Representatives, and his squad. Dan, this is Dr. Nathanson, the anthropologist I spoke about in the last meeting."

"So, you're the one that's going to show us how to deal with these blasted cats nobody knew about?" Tsielkovsky's bushy red mustache twitched and Julie saw the others behind him all staring at her curiously.

The Newcomers seemed different somehow. She had seen a number of other colonists in the hallways on the way to the lounge, and they all seemed to share a soft sameness that made all of them run together in her mind. But Tsielkovsky and his people were so refreshingly brassy and "real" that she relaxed a bit more. "Fellow Rip-Van-Winkles?" she asked.

Tsielkovsky looked puzzled for a moment, and then grinned reluctantly. "*Da*, Rip Van Winkles. That is good. Sleeping from 2041 to two years ago."

"What did you mean by what you said when you came in?"

"Just what I said. Those blasted cats—"

"He's talking about the fact that a survey patrol ran into a Cougar hunting party and was attacked," Jim interrupted. "One of the cats killed the geologist with a crude spear before they realized what was happening—"

"And that geologist was my brother," Tsielkovsky cut in.

"In a minute, Dan," Jim put his hand up. "The patrol was unarmed, but the shuttle pilot used some seismic test charges as crude hand-grenades and scattered the Cougars. None of them were killed, but I think one was wounded. They were terrified by the sounds of the explosions and ran. All of them."

"Star," Julie challenged the ceiling. "Do you have any footage of the attack, especially of the Cougar who was wounded?"

"Only a few crude stills, I'm afraid. They weren't recording. No need to."

"Can you throw a shot of the wounded Cougar, if you have one, on the screen and put it side by side with a shot of the sacrifice?"

"Interesting premise," Star admitted. "I confess I failed to make the connection for some reason."

"What connection?" Jim asked in an irritated tone.

"Just a second, please." She watched the screen change and saw the two shots of a Cougar portrayed on the screen, side by side. She grinned. "Points of similarity?"

"Enough for a positive I.D. They are the same."

"Great! And let me explain!" She warned Star as she turned to the others. "The wounded Cougar is unable to function as a hunter anymore. Look at the crippled hind legs and one destroyed eye. And I thought I saw burn injuries on it, too, which is why I wondered about any interactions with your people. But he or she—the Cougars may not make any distinction as far as combat—killed one of us. Now that warrior is being sacrificed and the other Cougars are drinking the blood. That parallels some primitive human tribal beliefs that eating parts of a victim endows the eater with the victim's assets. That means

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they are looking for a way to gain ability to kill us! They're planning an attack!" Suddenly she felt an incredible surge of relief and she saw Miller smiling admiringly. She winked at him, and then turned back to Jim and Serena. "How long ago did that sacrifice take place?"

"Six hours, fourteen minutes and thirty-five seconds ago," came the instant answer from above.

"Where's the nearest group of humans to the site of the sacrifice? And how long would it take the Cougars to get there?" She realized numbly that she had forgotten about the time that Gratch had spent examining her.

Jim looked up in alarm. "Star?"

"The closest group would be Agra Station 6. I am attempting to contact them now."

For several minutes, the room was tensely silent until Star spoke up, apologetically. "Jim, I need permission to override privacy directive and activate remote monitoring at Agra Station 6. They are not responding and I think we need to take a look."

"Agreed, permission granted."

"Thank you."

"Buggers," Tsielkovsky swore, his face getting as red as his hair. "I know blasted well what we will find. Those bugger cats have killed them all!" Behind him, the other freepers drew together and Julie heard a soft cry from one of them as the wall shimmered again.

As she saw what was on the screen, Julie gasped and grabbed for Miller who had come up next to her. They were looking in on a frightening scene of bloodshed. The main monitor was focused on the large, domed commonroom of the station. Four sprawled and torn figures were clearly in view, and the legs of a fifth were just visible off to the left, sticking out from under a counter of some sort. Each body's throat was viciously ripped open and from the bite-marks and the way that the heads were flopped at awkward angles, it was clear that each had been killed by having their necks efficiently broken. Three of the bodies were also extensively torn around the stomach and, in one case, nearly disemboweled.

The monitor image was brutally sharp and they seemed to be looking right into the room. Julie could almost smell the stench of death. She turned to Miller and buried her face in his shoulder, unable to keep from crying.

The portly physicist's face was ashen and he seemed to draw almost as much comfort from holding her as she was from being held. "My God," he wondered in a shaky voice. "Why didn't they call for help—"

"Or fight back?" Julie lifted her head, leaving a wet stain on Ken's tunic.

Jim and Serena had drawn close, too, and were equally shaken. Jim finally found his voice. "They didn't fight back because they didn't have any weapons. None of us do. Why would we need them? We intentionally made sure there weren't any because we are waking up people from a more savage time, and we didn't want any temptations or ways to express aggression."

"And they probably didn't call for help," Serena continued, "because they didn't expect to be attacked. We've been here for several years and the Cougars have always kept well away from us. We've been watching them, but we

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haven't wanted to interfere so we've made no attempt to contact them. Frankly, we've been a little shook up that they're even here. It complicates everything. We thought this was going to be our world. A new beginning for all freepers. A way that we could wake up all of you and give you a home—''

''About that,'' Julie let go of Ken after a grateful squeeze. *He really was a dear man,* she decided. ''Why were we brought out all the way here? I get the impression a lot—''

''All of the viable freepers,'' Jim cut in.

''OK, all of us were brought along. Why? Why weren't we revived on Earth and given a choice?'' A surge of resentment rose in her.

''Because Earth doesn't want you,'' Jim answered. ''They're afraid of the vestiges of the nanomachine plague that almost destroyed the Earth, and they're afraid of the mentality that prompted it. Out here, it doesn't matter. You're no danger, and even serve a useful purpose.''

The what plague? Julie wondered, getting irritated at being so much in the dark.

''It was Jim's idea,'' Serena supplied. ''It was the only way to revive you at all. The general desire was just to leave all of you sleeping until you were no longer viable.''

''To let us die?'' Julie stared at her.

An impatient voice from overhead interrupted them. ''Have all of you forgotten what we have just seen, and what it means?''

''No, Star.'' Julie reluctantly turned back to the gruesome image on the monitor, realizing this wasn't the time to pursue her question. ''It's called denial. Look it up in the psychology databanks. It's much easier to discuss something unrelated, rather than face a very harsh and shocking reality.''

''Oh.'' Star sounded thoughtful.

Julie turned to Jim. ''But just to warn you, I want to talk to you about this some more.''

He nodded. ''I promise to explain when there's more time.'' But she could tell he was already forgetting his promise as he studied the screen thoughtfully. ''How many were at the station, Dan?'' he asked finally.

''Thirteen, since we're here.''

''There are five bodies visible here. Can you give me any external views, Star?''

''Only two, there are no more external com-units.'' Two outdoor shots suddenly shared the screen. There was no one in sight anywhere, but there were clear bloodstains on the ground and scattered pieces of material and equipment.

''Any other interior monitors open?''

A quick succession of views flashed on the monitor, three holding on separate portions of the screen. The original view of the common room reappeared, as well. ''Nine victims accounted for. Four in three homes, and the five we first saw. I find no trace of the rest,'' Star finally proclaimed.

''They will have been taken back to their camp,'' Julie explained in a hollow voice. ''To be eaten, in all likelihood. In order that they gain our strength. It would fit the pattern. Also, these beings are carnivores and a full tribe would need a lot of meat. So the bodies would serve a double purpose. They probably

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left the bodies that were indoors because they were afraid of all the alien things around them. In the heat of battle, it's one thing to strike and exit. But to go back in deliberately might be something else.''

''But now what do we expect?'' Jim looked slightly queasy, and Serena was even paler than normal as she stood by the window breathing in deeply.

Star started to answer. ''It is—''

''I wouldn't worry about it,'' Julie cut him off firmly. ''Now they'll go back and celebrate. I wouldn't expect another attack immediately. This is a major victory for them. There will be time to warn everyone and to set up perimeter alarms and monitors.''

''What I want to know is why they are suddenly attacking after leaving us alone for years?'' Ken was confused, and Jim and Serena nodded agreement.

''Are you doing anything different now than the first few years?'' Julie looked at the screen uneasily. ''The Agra Station, what do they do there?''

''It's the pilot project for the farms,'' Tsielkovsky answered, his voice icy. ''We are, were,'' he corrected himself, ''clearing land and planting crops.''

''When did that start?'

''Just this year.''

''Well, there's your answer! You're encroaching on their territory. Even if it's a myth that wars always start over resources or territories, it is one reason some of them do start. Your land clearing is probably cutting into their hunting grounds. If they've been breeding as quickly as you say, they've got to be pretty pressed for a food supply. That would give more justification for the anthropophagy . . . felinophagy? Cannibalism.'' Julie shrugged.

A door hissed open behind them and Sayers entered anxiously. ''Jim, I just got a call from Bob Marks over at Bio and he's been trying to get in touch with Agra-6 and can't get an answer—'' He stopped, staring at the bloody montage on the wall behind them. ''What the chill?''

''Agra Station 6,'' Jim responded grimly.

''The Cougars? Why?''

Julie explained her theory as Miller came up behind her and wrapped his arms around her. ''And she thought she had lost it all.''

Somehow the gesture didn't seem presumptuous, and she had to admit to drawing a great deal of comfort from his embrace and she leaned into it, putting her hands over his arms to hold them around her.

Neither noticed Sayers's darkening expression and suddenly hooded eyes as he turned away, muttering excuses that he'd better let Bob know what had happened.

''Hold off on that, Mike, until I notify any surviving families,'' Martin cautioned.

''Right.'' Sayers waved and disappeared back out the door after shooting Miller a last poisonous look which was blissfully ignored.

Julie promptly forgot about it and chewed on a fingernail thoughtfully. After a minute, she looked up. ''Star, I want you to . . .'' she flushed and turned to Jim. ''Do you—''

''No, go right ahead. That's why you were revived.'' He looked up. ''Star,

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command Dr. Nathanson has command clearance *control*."

"Programmed," in a flat monotone, and then in his usual modulated voice. "Proceed, Julie, if I may call you that?"

She smiled. "Certainly. What I want you to do is to send out as many rovers, or whatever you call them, as you can to spy on the Cougars. I want recordings of their speech, correlated with their actions. I want you to gather as much information as possible to see if you can start figuring out their language. You would be better equipped to do that than I would."

"Thank you, but I need to warn you. There is a problem with monitoring. Video is not too difficult, but audio is a bit more complicated because of the distance we have to operate from. Ambient sound levels will interfere to a degree. We are working on neutralizing agents to make the monitors odor-free, but so far we're having limited success."

"Well, do what you can."

Speaker surveyed the battle site. It had been a noble fight and they had killed all the invaders in this place, without losing even one warrior. But why didn't he feel triumphant like the others? They danced around the bodies of their victims, drunk on the glory of the victory. The bodies outside the strange shiny caves. They had killed the sky-creatures inside, too, but had escaped out in the sun as soon as no one lived within. The smells and strange things inside had frightened the warriors.

Speaker's muzzle curled in an unfamiliar way.

Brave warriors. Celebrating a victory against beings who did not resist or even have any of the sensible self-protection he had expected. They had not even had any exploding rocks like the first group. He wrestled with unfamiliar ideas.

Was it right to attack them like this? The invaders were taking some of their hunting ground, but there was enough land that they could share. Could they not talk to the invaders about it? It went against instinct and tradition, but he kept having the same thought.

Then he saw the circling singlings. They had not yet mated or formed a Unit. There were not enough females in the Group at the moment. Six of them studied him carefully. Ringed-Tail's death had meant Speaker had challenged the oldest male for his mate. Crooked-Tooth had yielded without a fight because of Speaker's prowess, but he now circled with the others, probably the instigator. One more singling without a mate. Speaker considered sharing, but it was not right for the Speaker to be forming a Unit.

He crouched on his haunches and raised his fur. "You know the Law. Single to challenge."

"That is for warriors," Crooked-Tooth growled. "You killed no sky-creatures today." A harmony of growls accompanied the accusation.

Speaker fought to keep his fur erect as he calculated the odds. He would never triumph against six of them and they did have the right. He did not realize they had been watching him, waiting for a sign of weakness. They were counting on killing him, knowing he would take two, maybe three of them along to their ancestors—he was, after all, Speaker, and had beaten all chal-

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lengers in the past. But with him gone and at least two of them dead as well, there would be a female freed and the survivors could challenge for her. Because of the great need for food, all of the Group hunted and fought. But in matters of breeding, females were traditionally subordinate since they were useless while pregnant.

Speaker watched the singlings warily, his only option clear.

Slowly his fur dropped and he relaxed his crouch towards the ground, turning his head to the side as if to surrender—and then he exploded into action!

He rolled to the side, towards Notch-Tail and sprang to his feet after a full turn, jaw thrusting forward and fangs extended to rip his throat open in a single sweeping slash. At the same time he snatched a large rock he had spotted before and hurled it with deadly accuracy at the side of Splotch-Back's skull, hearing the wet crunch as it cracked the bone. Before the others could react he sprang directly between Six-Toes and Thin-Fur, pulling his slate dagger. Thrusting at Thin-Fur's throat with the dagger, he clamped his teeth onto Six-Toe's shoulder to pull the smaller male down. He felt the dagger strike home and felt a warm flow of liquid over his right arm and let go to attack Six-Toes better.

But the smaller male rolled onto his back and retracted his claws in surrender, exposing his throat and belly. Speaker ignored him, turning briefly to see Thin-Fur lying on the ground, eyes glazing over as blood spurted freely from a severed artery in the neck. He faced the other two shocked singlings with a spitting snarl, fur matted with blood and eyes blazing as he challenged them. "Who is not a warrior?"

Crooked-Tooth and One-Ear stared at the four singlings on the ground and dropped immediately into submissive postures and offered their throats, though Crooked-Tooth's eyes burned hotly. Speaker ignored them and went to inspect his victims.

Notch-Tail and Splotch-Back were both dead, but the latter without honor. Speaker bent and sank his teeth into the dead male's throat and ripped it open; the taste of the cooling blood bitter in his mouth. Thin-Fur was not yet dead, but he was close to the end. As he saw Speaker approach, he raised himself up and offered his throat, eyes pleading for honor. Speaker obliged. They had had the right to challenge.

Then he turned and found himself confronting the rest of the warriors. As the six had begun to challenge Speaker's authority, they had been watching unobtrusively, waiting to see the outcome. Now they came forward and, one by one, briefly crouched as both males and females turned their heads in submission when they filed past.

As the others gathered those sky-creatures' bodies that lay in the open, Speaker realized that there would never be a better time to try to make a radical change.

They were in a long, brightly lit chamber, standing at the beginning of a seemingly endless row of the same coffin-sized container as the one she had awaked next to. Julie glanced over nervously at Sayers. She had been dying to see all the other freepers who had

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been brought along, and to learn about how she had been revived.

So, against her better judgment, she had accepted Sayers's invitation for a tour of the freeper-halls, and Sayers had begun his spiel, obviously aimed at impressing her.

"This is where we bring them, five hundred at a time." He indicated the line of vats. "The vats contain specialized breeds of nanomachines that evolve or are replaced, as different stages of the revival process are reached. We start the thawing along with the first level of nanomachines that are strictly aimed at repairing any cellular rupturing that may have occurred. Technically, there shouldn't have been any with the later more refined techniques used. But in actuality, there was often some degree of damage in poorly perfused areas of the body, depending on the state of the circulatory system."

But as he talked, her mind drifted. Jim had already explained it to her, and in a much more interesting way. Sayers was just trying to impress her, jealous of her interest in Miller. She smiled faintly as flashes of memories from her high school and college days teased her mind. She had been pursued then, too, she remembered. All the more so because she had resisted all attempts at conquest, more interested in her search for the truth about humanity's beginnings: a fire lit by her parents, both of whom were anthropologists.

She had had no patience for the infantile courtship rituals of pubescent boys with delusions of manhood. Or that was what she had thought, then. Later, she had regretted missing out on some of the joys of youth. It might have prepared her a little bit better in handling personal relationships later on. But now, suddenly, she was the object of desire again and liked it this time. And she knew why Miller appealed to her. He was the type of man she had always desired. An intellectual equal who would not only accept her strengths but expected and complemented them.

Sayers, on the other hand, was the grown equivalent of the very juvenile types that had turned her off when she was young.

Sayers mistook her absorption and, encouraged by what he thought was her fascination, rattled on.

"We have an almost perfect revival record now," he told her proudly, "because a new method of testing the freepers was developed that is almost 100 percent accurate in distinguishing those freepers who are viable from those who are too damaged to revive. We tested all the freepers on Earth before we left, and only brought along viable ones."

Forty thousand, out of two million, she thought numbly, remembering what Jim had told her. She had finally pinned him down for an explanation of why they had been brought along so presumptuously. But he had been caring and sympathetic as he had explained. Not as coldly callous as Sayers was when the freeper-upper calmly talked about destroying almost two million human bodies.

Surprisingly, almost none of the freepers that had been brought were those with terminal diseases. The early cryogenics processes had been too crude, and later on, terminal illnesses had not

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been the source of worry, instead, nanotechnology run amuck had been.

She had been shocked by what she had learned, but grateful for the way Jim had told her. He had begun by showing her pictures of Earth as it was now. A verdant living world again. But all too soon she had wondered at how empty it seemed. And she had been told why. The same technology that had cleaned up pollution, provided cheap, clean power and restored natural resources had first been perverted into virtually unstoppable weapons. Microscopic killing machines capable of reproducing themselves, that terrorists had released by accident. The nanokillers had not been programmed for specific targets, so once unleashed they had spread over the world and destroyed almost half of its population, helped by an improved mass-transit system and an unsuspecting world. At first.

When it had become clear what was happening, escaping by being frozen had become the way out for millions. Many had been taken advantage of by con-artists or badly designed freezing techniques. Only two percent of the frozen had been 'salvageable.' She still cringed at that word. Sayers's not Martin's.

But the machine-plague had finally been stopped by another nanoorganism and the world had licked its wounds and cleaned up, eventually. But the frozen millions residing in vaults all over the world were a brutal reminder of the assault the world had suffered through. And another suspicion also built up gradually: the worry that reviving the freepers might mean a revival of the same attitudes that had caused machine-plague in the first place. And there was also an increasing fear that some of the nanokillers might be lurking inside the frozen bodies, waiting to be released again, no matter how good the safeguards might be.

She was glad she had slept through it all!

Sudden, expectant silence made her realize that the freeper-upper's speech was finished. She roused herself to smile. "Fascinating, Mr. Sayers, really," Julie tried to cut him off. "But I have to run, I'm afraid. I have an appointment with Star to go over the records on the Cougars," she excused herself and headed for the door. She was suddenly anxious to get away from the cold clinical world around her.

Sayers made a last try. "Can I—"

"I'm sorry. I'm really going to be rather busy, you understand. I have a lot of catching up to do. I'll call you." She waved goodbye and ducked through the door at the end of the hall, drawing in a deep breath of the sweet air outside. As it hissed shut behind her, she moved to the side and leaned against the warm metal wall, tilting her head back to feel the sun beat on her face.

She still felt a little surprised. She had learned that the sun StarStep revolved around, Barnard's Star, was a cooler, red dwarf star. Somehow she had expected it to be a looming red globe in the sky over them since they were so much closer to it than Earth to its Sun. But the sun overhead really seemed no different to her eyes. She could almost forget where she was—until she moved! Then she was suddenly reminded of where she was.

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The whole colony was unsettling like that.

Star had shown her a holographic model of StarStep City, and looking up and down the wide avenue in front of her, she had this strange feeling she was just standing in a larger version of that neat and sanitary picture. It was too clean! It was like a city of the future in a mid-twentieth century movie. Antiseptic streets and domes on the surface, and a warren of bright and spacious apartments below-ground; each seemingly on the ground thanks to eerily realistic holo-screen images of the surface. At least the administration-tower's windows had been real! She longed to head out into the country and get lost in the woods. Or at least pretend to.

She closed her eyes tightly as she was overwhelmed by a longing for home, normalcy, her memories . . . and suddenly she wanted to be held. Sayers's lechery, the sudden and brutal shocks of the last day and a half; they were all piling up.

"Julie!" A familiar, and welcome voice broke into her misery and she turned to see Miller come up, a concerned look on his face. "Are you OK?"

She blew out an explosive sigh of relief. "I am now. I just got overwhelmed by everything new, and of Sayers trying to hit on me—"

"What?" Miller jumped forward and inspected her anxiously, stopping with a confused look as she laughed.

"No, not physically! A term from my youth. It means he was trying to make a move on me . . . make a pass . . ." Miller shook his head. "Trying to flirt with me."

"Trying to link!" Miller's face cleared, briefly. "Did he—"

"No, he didn't get too pushy. But I had the feeling . . . I don't know. Maybe I'm imagining. I just didn't feel comfortable in there." Then she pushed off from the wall and tucked an arm under one of his, feeling safe and comfortable. "But I am glad to see you. I have a few questions to ask you." She grinned at him.

"Like what?"

"Like how come you cultivate that?" She patted his belly gently. "I'm sorry if I'm getting too personal, but I'm just curious. Except for you and Jim, all of the non-freepers around here look almost alike. Black, white or Oriental. Is this your way of being unique in a conformist world?" She took a guess, remembering what Jim had said about everyone's health being maintained by nanorooters.

Miller nodded slowly, giving her an appraising look. "As I said, you may have forgotten a few facts, but there is nothing wrong with you."

"Next question: is there anyone in—"

"In my life romantically?"

"Yes."

"Not yet." He grinned. "But someone seems to be working on that. Not that I mind."

"Direct, aren't you?" She was suddenly embarrassed.

He smiled gently. "You aren't exactly beating about the bush, either. I like that. And as for me, would you want my attitude any different?" He stopped and turned her to face him. She shook her head immediately and he smiled. "Good. Sit down." He indi-

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cated a molded plastic bench on the side of the walkway between the buildings.

As they sat down, he sighed and was silent for a moment, staring into the distance. She waited. Then he turned to her and smiled softly. "There was somebody. Years ago. A gentle woman. A brilliant artist. She could look at the ugliest pile of trash, and find beauty in it. Rearrange it and photograph it in some special way. Or paint or draw it. And she liked what she saw in me. No correlation, I hope. Of course, I looked a little different then." He grinned and looked down into his considerable lap. "Didn't have this, for one thing. And my hair was charcoal black. I was rather handsome, if I do say so myself." He stopped her from saying the obvious. "Maybe I still am, but in a different way."

He stopped for a moment and looked out in the distance, remembering. "I was a student at MIT and she was supporting us. Not a starving artist, her." His face glowed with love and pride. "Even then, no one who saw her work was unmoved. Or untapped financially. She was shrewd at business, too. A rare combination. She had galleries competing for her work and took them for all she could." His voice suddenly broke. "And then, in '40 my world ended."

Julie realized what was coming. 2040, that had been the year nanokillers had been let loose on the world.

Miller saw her face. "You can guess what happened, I see. She was in Seattle for a trade show when an outbreak of the machine-plague hit it. Eighty percent of the city was wiped out. There weren't even bodies left. The nanokillers liberated all the water in the bodies and transformed them into raw elements that blew away on the first breeze. "Dust to dust . . ." Tears were running down his cheeks and she felt her own eyes burning. "Do you know how long it's been since I told anyone this?" he asked. She shook her head. "One hundred and thirty-eight years, roughly. I was going to therapy for a couple of years afterwards. And then I stopped. I let myself go to pot at first. And then I didn't have time to worry about my physical condition because I sunk myself into my work. And when I had a chance to rebuild myself I decided I didn't like the homogenous nothingness of the "healthy" new bodies, so I kept this newly developed friend," he patted his belly again. "My mark of distinction, of difference." He stopped, staring at the ground.

"At first I couldn't even imagine there ever being another woman, and later I didn't have time," he went on, after a moment. "So it didn't really matter how I looked."

"Does it, now?" she wondered.

"Does it to you?"

She thought for a minute, and then shook her head. "Not really. It's only a small part of you . . ." She chuckled. "Sorry! I meant it's only one element of you—"

"That decides it. It's coming off." He looked down mournfully. "Sorry my friend, but you're going to go. We've had a lot of good years, but it's time for us to go our separate ways." He glanced over at Julie who was having a hard time keeping a straight face as she saw Ken's woeful expression. "I just have to tell myself that it means

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being able to see my feet when I'm standing up!''

She leaned over and kissed him impulsively, not resisting as he pulled her close and returned it with unexpected but welcome hunger.

Out of the corner of her eye, she thought she saw Sayers vanish back into the freeper hall but she ignored it as she melted into Ken's embrace.

''If I fail, I am no longer Speaker,'' he offered. ''Why is it wrong to talk to the sky-creatures? Where is it said it is wrong?'' he challenged. He was counting on that question. Since they had never encountered this before, naturally there was no tradition against it. He knew that the others were struggling with some of the ideas he had come up with, and he was counting on them not thinking quickly enough to argue.

''I am Speaker,'' he pressed. ''It was I who showed long sticks that kill, I who dug the first pit with sticks to catch food, I who showed you how to chip stones for claws harder than claws. I am your leader, and I say we should do this. We have shown them our strength and they should know to fear us. And now is the time to try to make peace, while we also have their strength in us.'' But did they? Speaker's stomach still churned from eating of the sky-creature's flesh. The smell, and the taste. Full of flavors best unsampled.

Crooked-Tooth, still seething, spoke up first. ''You will go to the sky-creatures alone? What if they kill you? Who is Speaker then?''

Not you, Speaker thought firmly. He considered the males, and even considered a couple of the females briefly. Sag-Belly would have been good. She was not the strongest, perhaps, but she was blindingly fast and she was intelligent. That was needed for a Speaker or they would go back to being a starving tribe eating their own in cold times. *Like the tribe on the other side of the mountain they had scouted last warm time,* he remembered. But a female Speaker would never be accepted, he knew. But there was Six-Toes. He had surrendered, knowing he was beaten. Which was no dishonor. And he, too, was a good fighter, even if he was small. The challenge had not been his idea, and Speaker did not hold it against him.

He decided.

''Six-Toes will be Speaker, and get my female if I don't return in two hands of lights. His hands.'' He exposed gleaming fangs in a savage grin, seeing Six-Toes respond in kind. ''And he will act as Speaker until I return.'' Let Crooked-Tooth and Six-Toes keep each other busy. Crooked-Tooth might be a better fighter, but he was stupid and nobody liked him. They would support Six-Toes to prevent Crooked-Tooth from being Speaker. And it might keep Speaker safe from an ambush. Six-Toes had no wish to be Speaker for more than a short time, but the desire had been plain to see on the older singling's face.

He turned and took up his pack and stick, glancing back briefly at the gathered tribe. ''I will be back.''

He set a brisk pace immediately, leaving the Gathering Place behind him, thoughts whirling madly. He had another problem to consider while traveling. Since he had been Speaker, the Group had not grown, and fewer younglings were being born. Each litter was

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the same size, and while more of each birthing were surviving, the birthings came less often now than in his forerunners' times. He remembered being a youngling, and how frequently birthings occurred, and he remembered his mother saying that there were less birthings in her time than in her forerunners'.

Speaker knew he was one of a few who held memories of their youngling-times, but he was glad that he did. If there were less birthings but just as many deaths? What would that mean? He would have to think.

But first he had to keep a war with the sky-creatures from starting!

He suddenly noticed that the sun was dropping low and realized he had been walking all after-high-sun-time. And he realized he was sore. Dropping briefly to all fours, he shook himself and stretched, feeling a sore protest through his body. He also felt a rumble from his stomach and knew he would have to hunt soon. But first, he needed to rest.

He crouched on a nearby boulder, feeling the warm rock soothe him. But then his ears swiveled restlessly, as he heard a faint rustling in the underbrush.

Julie looked around, a little awed. Several dozen people sat around her, along a long arcing table, with Jim Martin at the middle. Not too long ago, Jim had seated her in a small chamber which had then suddenly expanded into a huge conference room with all the colony's Representatives in attendance. It was a holographic illusion that defied detection.

Every expression and nuance of face and voice was clear, and she was getting more and more angry as she listened to one particular viewpoint being pushed, hard.

"I say we wipe them out! They're hardly more than animals!" Tara Richman was a lanky brunette woman with short, bobbed hair, standing near the right end of the table. She was Representative for a sizable portion of the roughly three thousand freepers thawed out so far, and by far the most militant.

"Tara, don't you think that's getting a little extreme?" Dan Tsielkovsky looked uncomfortable where he sat, a few seats to the right of Jim, directly next to Julie. He was also anti-Cougar, but at least he was less extreme.

But Julie had had enough. She got to her feet and interrupted, glaring at Richman. "How can you stand there and talk about exterminating an entire race of intelligent beings?"

"Hey, they were an accident. This was supposed to be our world. You screwed—"

"Don't you 'you' me. I'm one of you. I'm a freeper, too. Hell, I'm senior to any of you if you want to get technical. I admit I'm not exactly happy about waking up six light-years from Earth, rejected by my own world, either. But I'm alive and I have a chance to be a part of history here! I happen to be pretty excited." To her left, she heard murmurs of support, and she even noticed a few grudging nods from other Representatives near Richman.

But the other woman refused to budge "What about when another thirty-seven thousand of us are up and around? We need to clear land for building and farming and not have to worry about a bunch of blasted cats that breed like crazy!"

Julie laughed. "We have a whole

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bloody planet! And there are only a couple of isolated tribes of the Cougars. Other predators exist in different areas, and they're not intelligent. Star estimates that there are only about 20,000 of the Cougars, all told, including the non-intelligent . . .'' she stopped and looked up. ''Star, you tell her.''

''Gladly.'' She shivered. He did have a marvelous voice. ''Representative Richman,'' Star began. ''There are currently four or five loosely scattered tribes of intelligent Cougars, with a total number of eight to nine hundred, as near as our surveys can determine. They're far outnumbered by the non-intelligent cougars scattered throughout the northern and southern temperate zones. These are either from non-damaged stock or in interbreeding, the altered strain was diluted and they have reverted to baseline.'' Star's voice was suddenly condescending and Julie forced herself to keep a straight face. ''And as for rapidly breeding intelligent Cougars being a threat: I don't think you need worry. They have a high mortality rate and since their reproductive cycles are reverting to normal, they are not likely to overrun their established hunting areas. If anything, unless they establish a more settled social structure, they are actually in danger of extinction. That is because they are continuing a pattern of behavior that was both good population control and evolutionarily progressive during the early decades of explosive breeding. Life is expendable, and challenges to the death are common. That was fine before, but now, when the birth rate is dropping, it is proving to be attritionary.''

Julie stared up at the ceiling. That she hadn't realized.

Background noises were suddenly cut out and Star went on in a different tone. ''Sorry Julie, I just found that out when I reexamined my data. The others don't hear this private comment to you, by the way.''

''Thank you, Star.''

A faint feeling of sonic depth warned her that she was back on contact with the rest of the Representatives. Richman seemed to have been effectively shut up for the moment by Star's quiet revelation, and more than a few of the others looked mildly pleased.

Jim took advantage of the momentary silence. ''Well, since it seems that we have settled that for the moment, maybe we can have some constructive suggestions on how we should go about protecting ourselves. Thanks to Dr. Nathanson, contact efforts have begun; with an attempt to learn something about the Cougars' language. So, let's begin by planning for self-protection.''

Julie felt her interest wane, her mind still churning on about Star's latest revelation and she tried to remember which switch Jim had thrown to activate the holo-link. Suddenly the illusion collapsed and she was alone again.

''I take it you wished to terminate?''

''Are you a mind-reader, too, Star?''

''No, a palm-reader. I saw your palm groping.''

Julie giggled. *God, she was doing a lot of that lately!* ''Star, this may not mean anything to you, but you'd be the perfect straight man, with your delivery.''

''Well, I am straight, on six sides.

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A multifaceted individual you might say."

"Touché. Not to change the subject, but can you call Ken for me?"

"Certainly. I'll even call Ken Miller, not one of the other seven Kens that my present census shows to be active, if one uses Ken as a diminutive for Kenneth as well as a name on its own."

Julie shook her head in admiration. Serena had done a hell of a job programming Star. But he needed to learn when to stop joking.

After a moment she heard Star's puzzled voice. "Dr. Miller is not responding. Instructions?"

"What about his locator?" She remembered Jim telling her that all StarStep personnel were tracked via implanted beacons, in case of an accident when away from City.

"I am not getting a reading." The simulated concern in Star's voice translated to panic for Julie and she bolted for the door. "Call Jim and get a search organized! I'm heading to his room—"

"Don't bother . . . I overrode the privacy directive—I can do that in an emergency—"

"Don't defend yourself, damn it! What did you find?"

"Sorry. His apartment is empty. I scanned it."

"Shit!" For a minute, she stood by the door, thoughts whirling madly. Then she remembered a comment he had made before. "If he wanted to go get modifications done on his body, where would he go? What would he do?"

"Contact one of the bio-nanotechnologists and request a make-over. It's simple enough, unless he wanted radical changes in which case I would be needed to program the nanorooters. Standard modifications are already preprogr—"

"Like Sayers?" Julie had only heard the first words. She suddenly recalled Sayers obvious jealousy over her interest in Ken. "He would have himself knocked out with a whole crop of miniature machines crawling around inside, controlled by Sayers?" She knew she sounded almost hysterical but she couldn't help it.

"Yes, or any of the others. There are over a dozen bio—"

"Would that throw off the beacon?"

"Yes, and—"

"Check on it . . . can you check somehow if anyone is getting," she choked on the word, "worked on anywhere?"

"Working . . . Yes. In Med-Block-2, but my access seems to be blocked. I—"

"Location on Sayers," she demanded, heading out the open doorway.

"Med-Block-2—"

"Guide me!"

"Certainly. But it seems that my sensors there have been blocked." Star repeated, sounding confused, but the room was already empty.

Speaker spun as two feline figures materialized silently from the bushes on the path ahead. He automatically dropped to a crouch and pulled his dagger, fur rising along with his warning growl. Ahead of him the two unfamiliar warriors dropped and bared their bellies.

"We are here to protect you, Speaker," the smaller of the two explained. She was a young female with

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delicate shadings of brown and white, and an unusually long tail.

Speaker's hair flattened, but he didn't sheath the dagger. "Sent by who?"

"Six-Toes," the large male answered with a peculiar spitting sound. "He doesn't want to be Speaker, so he thought it would be good to make sure you came back safely. I am Marrow-Sucker, and this is Long-Tail."

"You're late."

Both strangers rose, looking puzzled. "I don't understand," Long-Tail was first.

"I don't understand." This time it was Marrow-Sucker's turn.

"I didn't want to bring an escort and risk looking weak," Speaker explained. "Or have anyone think I was worried about being unable to do this."

"How did you know Six—"

"Because he doesn't want Crooked-Tooth as Speaker any more than he wants to be Speaker himself. He wants a female, and continued prosperity. Not to be challenged all the time. And he doesn't want the problems everyone would have with Crooked-Tooth as Speaker. The tribe doesn't need a stupid Speaker." He sheathed his dagger and looked over the two still-confused warriors with an approving yawn, his fangs glistening redly in the dying sun.

Six-Toes had chosen well. Both warriors were lean and muscled; their postures and attitudes vigilant. Speaker felt a bit more confident than when he had first started on his trip to the sky-creatures' city.

Med-Block-2 was fairly small compared to the other blocks. It consisted mainly of a single, large, square room. Set into three of its walls were retracting nano-rooter modification chambers, two on each wall. All but one were empty at the moment, and in the elevated control area in the middle of the large room, Sayers stood, busy monitoring a display panel.

As the door burst open to admit an anxious Julie, followed closely by the concerned duo of Jim and Serena, Sayers spun with a curse. "Who the hell . . ." He fell quiet.

"Where is Ken?" Julie demanded, an edge of panic in her voice. She started up the steps to the controls but Jim held her back.

"Yes, where is Doctor Miller?"

"In there," Sayers pointed to the active chamber. "He'll be there for another couple of days. Didn't you get his message?" he asked innocently.

"Message?"

"Yes, he told Star to tell you he was going to be busy on a rush project and would be out of touch for a couple of days. He was having himself rebuilt, as a surprise."

Serena stepped around Jim. "He told Star to lie?"

"Sure, he has over-ride priority to control Star."

"Just what did he tell . . . Star," she stopped and looked up. "I know you can hear me but just can't assimilate anything except control commands, so *control* reset *command*," her voice snapped firmly.

"Thank you Serena, what happened?"

"Do you remember Doctor Miller's orders?"

"No. What orders?"

"Memory wipe, too. Great!" Her

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mouth tightened into a slash. "Star, interface with Lab-Data and monitor Doctor Miller. Status report."

After a moment, a calm voice. "Dr. Miller is in excellent shape, literally. Just a little smaller, and shrinking by the hour." A hesitant electronic chuckle filtered down and the others all stared up. "Was that appropriate, Dr. Andrews? The situation fits the parameters my records indicate as 'funny.' He has had his waistline and weight reduced to what would be appropriate for his height, in contr—"

Serena ignored him and turned to Sayers, who had a satisfied grin on his face. "What did he order Star? Remember, Ken will be awake soon and can confirm."

"Oh," Sayers responded, "he told Star, in command mode, to program some nanorooters for a slimming and reshaping session, to give his excuse to Dr. Nathanson as soon as the reshaping was going, and to forget all instructions as soon as he was asleep. He also left a command to keep Star blocked out of Med-Block-2 until reset. That way Star wouldn't be able to answer any direct questions, even in command mode." Sayers shrugged. "I guess Star forgot to deliver Dr. Miller's message to Dr. Nathanson, too."

"That's the way he instructed Star? In that order?" Serena pressed.

"That's right."

"So Star didn't deliver the message because he was told to forget it before he was to deliver it. You knew damn well that that would happen."

Sayers looked innocent. "No, honestly, I didn't think about it. I assumed Star would understand what Dr. Miller meant."

"Not in command mode he wouldn't." She turned to Julie and clasped her shoulder. "He's fine."

Julie let out a sigh of relief.

Sayers gave her a nasty smile. "Sorry to distress you."

"That's fine," Julie shrugged. "I'm just glad he's OK."

Sayers looked confused as he came down the steps towards her. "No hard feelings?" He sounded disappointed as he approached her, searching her face with his eyes.

"No." She started to turn away as he reached her, and then spun and slammed her open palm across his face with an echoing force that rocked his head back and sent him staggering. A red handprint grew brighter by the second over the side of his face. "No hard feelings. On my part." Then she turned and, with a sweet smile to Jim and Serena, left the room with a brief parting comment. "Could you have Ken call me when he's awake, please?"

Speaker stared at the strange caves ahead, his black-pupiled yellow eyes slitted against the evening light. The caves glowed red as they reflected the dying rays of the sun. They seemed as smooth as a lake on a windless day. It was the same strange material as the caves they had attacked a hand of lights past, but bigger.

His stomach grumbled and he felt like he was a singling facing his first mate-challenge.

He could see a couple of the strange sky-creatures walking around, tiny in the distance. Short and stocky. Pink and

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hairless, but covered with strange brightly colored pieces of . . . something. He had thought it was their skin, but they shed it too easily, he had seen. He had watched them before. And if it was discarded skin, why would they put it back on again? And why were they different colors?

Questions, always questions running through his mind. Sometimes Speaker wished he was not thinking so much.

From across the field, the stench of the sky-creatures came floating again, carried by the shifting wind. Speaker's nose twitched. That would be the hardest to deal with. He forced his fur to lie flat and turned to his companions.

Julie was sitting on the grass in front of the administration tower, watching the jungle across the lawn. It was almost a thousand feet away—about three hundred meters, she corrected herself. Even England and America had finally surrendered to the metric system as the milennium had turned. She had been sitting out here for several days now, and encouraging other colonists to join her and move around outside.

"Julie?" A gentle voice called from the computer on her belt.

She lifted it up, the delicate three-dimensional moiré pattern floating in front of the screen identifying the caller. "Yes, Star? You sneak in everywhere don't you?" She smiled, for the hundredth time imagining a face to go with his voice. He was awfully comfortable to have around sometimes. Though she had expressly barred him from her apartment unless she called him. That was too familiar. He was too human in a lot of ways.

"I was wondering why we do not contact the Cougar who is watching us. It is the same one who performed the sacrifice. Do you not think he is scouting for an attack? We should try to convince him not to."

"I disagree. That's what I told the Council, and you heard my reasons. I don't think he's scouting for an attack. Gathering information, yes. But I would swear he is trying to work up enough nerve to contact us. The other two are behaving normally. Staying out of sight, growling, spitting and fur-ruffling like any house-cat whose territory is being invaded. But the leader, he's got to be, he's watching. He's curious, not angry or scared." She smiled. "We've got a feline Einstein here."

"What are you basing that on?"

"Gut instinct."

"Oh." Star sounded a bit miffed.

A slender finger tapped the top of the computer rhythmically as she pursed her lips in thought. Star's identifying pattern swirled and she grinned helplessly as she thought of something. "I hope this isn't getting you excited, dear."

"What?" Total confusion. He was getting better and better at simulating.

"Are you trying to hit on Star, my dear?" Suddenly a pair of warm arms crept around her and lifted her to her feet effortlessly. A familiar scratching brushed her cheek as a snowy beard crept onto her shoulder. But she felt a chest behind her, not a stomach and spun in surprise, grabbing hold of him and squeezing tight. "Ken! You're all right! Thank God!" She grabbed hold and squeezed tight, able to link her hands behind him, now. Then, she

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leaned back and took a look at him, eyes wide as she saw the "new" Ken.

The salty hair and ebony skin were unchanged, but on a rugged figure with a flat and rock-hard stomach. The face was more defined, too. But the eyes were the same: warm and twinkling with good humor.

"I didn't change too much," his familiar and deep voice boomed cheerfully. "I will keep my snow. I've earned it. But I thought this body would be better suited for a little camping in the woods. I imagine that as an anthropologist with a whole new species to document, you'll want to be doing a bit of that. I won't have time to be with you always, but I can certainly manage to delegate enough work that we can have some time together in the wild." He eased out of her arms and pirouetted. "Well? Do I meet with your approval?"

She shook her head, almost as overwhelmed as with her own transformation. "I had no objections to the old you, but I do have to confess that I like the redesign." She cocked her head and examined him critically. "Yes, I think I'd have to stamp you USDA prime, but not with Star watching." She leered and eyed his rear.

"USDA prime?"

She shook her head. "Never mind. Obviously before your time, but believe me, you're choice." She grinned at his continued befuddlement and then stepped forward, grabbing his ears to pull his face down. Then she gave him a resounding kiss, after pointedly hanging her computer back on her belt, screen and "eye" turned in to block them. "I love you," she finally said softly after a long, delicious moment. "But don't ever try to surprise me like that again!" She twisted his ears lightly. "I was scared out of my mind!"

"I promise."

"Good." She let go and with a sigh pulled her computer back up. "Star, I had an idea, before I was interrupted." Her eyes twinkled. "I want you to design a holo-simulation for me. Can you do a—"

"Remote projection where our visitor can see it?" Star finished as Julie frowned. "Yes I can. I will need some equipment set up to receive the signal. But we can do it from under the surface so we don't scare away the Cougars. We'll tunnel from beneath and just extend the terminals over the grass when close enough."

"Fine, now here is what I want . . . and don't second-guess me—"

"Define, please."

"Don't interrupt me or try to anticipate me!" She gave Star's swirling pattern a mock glare as she explained what she wanted.

Speaker had been watching them for several lights now. Too long. He had promised to return to the tribe in two hands of lights. Two of Six-Toe's hands, but still not that long. He had already been gone for one of those. One of the sky-creatures was the same one, every day, he was realizing. Its smell was the same. A different smell, like flowers, was hidden under the normal rankness. It was a different color each day as it covered itself in something different, but he was starting to recognize it. It had long black fur on top, which looked strange since it had no other fur he could see.

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A different creature had been there in the before-high-sun time. It was dark, with white fur on its muzzle and head. It had embraced the black-furred one. Mating?

The idea of the sky-creatures mating made them seem less alien. Different, yes. But no longer so frightening. If they mated, maybe they felt pleasure? And if they felt pleasure, then they felt pain. Thoughts spun in his head again.

A hiss from behind alerted him, and he turned to see Marrow-Sucker pointing at a nearby section of the short plants that stopped the jungle. He could see nothing, but he felt it. The ground was trembling, and a faint new smell, a dead smell like the inside of the shiny caves teased his nose. Then he saw it. The ground was moving. Two shiny metal sticks came out of the ground like some monster under it was testing the air. He felt Marrow-Sucker and Long-Tail pull away. He smelled the fear on them. He felt his own fear, too. But he was unable to move. He wanted to see what it was.

Then a mist came over the field. He saw himself, standing on the short plants by the shiny caves! He heard his guards growling behind him, confused as they looked from the real Speaker, to the odorless image standing out in the open. Then the black-furred sky-creature came walking towards the false Speaker, paws extended. It was holding a dead field-runner. A healthy, fresh-killed one. But again, neither the sky-creature or the prey held any smell, and the three hidden warriors were confused. Even more, because they could see that the black-furred sky-creature had not moved from where it was sitting over by the shiny cave.

The false sky-creature came right up to the false Speaker and held out the prey. And then Speaker saw himself reach out and take the prey, actually touching the sky-creature. Then the sky-creature turned its back (!), and walked away. And the other Speaker did nothing, but simply walked the other way.

Then the mist cleared, and there was nothing. No other Speaker, no prey. Just two metal sticks coming up through the ground and the black-furred sky-creature sitting by the shiny cave like before.

Speaker turned, trying to understand what he had just seen. He realized both of the others were crouched, fur erect and fangs bared, a low moaning growl warbling from their throats.

"Stand," he spat. "There is no danger!" Reluctantly the others straightened, their fur slowly settling, though their teeth remained bared. "I came here to contact the sky-creatures, but the sky-creatures are trying to contact us!" He realized finally that that was what it must have meant. He felt his heart racing. He turned to Long-Tail, a terrifying idea growing. "Go catch a field-runner or a tree-hunter."

"You are hungry?" She stared at him in disbelief.

"No. I intend to try something. What I came here for." He knew the young warrior didn't understand, but suddenly he felt compelled to try his idea out. No matter how much it repelled and frightened him.

Jim and Serena stood by Ken and Julie. They had also watched the holographic illusion play itself out a while earlier.

"Do you think it's going to work?"

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Jim wondered for the sixth or seventh time.

"I don't know." Julie shrugged. "I do know that he is an extremely patient and curious cat. Totally different than the other two. When the Holo-projectors came to the surface, the two with him looked like they couldn't decide whether to take off for the hills or attack. He just watched it, and even moved closer."

"Excuse me," Star interrupted. "But the female Cougar that left is back and has a freshly killed doe with her."

All four of them exchanged amazed looks.

"It might be working at that," Jim exclaimed.

Julie got up off the ground and brushed herself off, her mouth suddenly dry. Ken came up to her and took her hands.

"Are you OK?"

"Does it show?" Her heart was racing. She didn't dare hope the Cougar might actually try to copy the image, but if he did, it meant having to face him directly. An animal . . . *No!* she corrected herself firmly. A native, who had calmly slit the throat and drunken the blood of a fellow warrior, and who had led an assault that had taken the lives of thirteen defenseless people. Was she scared? Bloody right she was! She grabbed hold of Ken and squeezed him tight. "Better get out of sight. Just monitor me through Star." She let go of him reluctantly and urged them all away. "I want to be alone, and closer to the jungle so he won't be as afraid." She laughed; a brittle sound. "He's probably as scared as I am."

As soon as they were out of sight, she drew herself up and turned back to the jungle. "Well, here goes." She started towards the jungle. "Are you with me Star?"

"Every step of the way," his calm voice reassured her. "I'm afraid I don't have anything useful on the language yet, but at least I may be able to warn you of any threatening sounds, moves or gestures. I have quite a collection of those. Also, I have a laser aimed at you. Jim dismantled a portable communications link and wired it into me. I will be able to distract the Cougar quite effectively if he should make a threatening—"

"Not unless I tell you to!" Julie stopped and lifted the computer. "Absolutely not. With all cats, there are displays and threats that are part of establishing communications. And I don't want anything to blow this opportunity. Unless I tell you, or unless he physically injures me do . . . not . . . do . . . anything! Clear?"

"Certainly." He sounded so hurt that she had to laugh. "OK. I'm sorry. I'm sure that information is in your data banks, too. It's a shame you don't have any records of a meeting between members of two different tribes. That would have been perfect."

"He's watching," Star warned.

She realized she was within twenty meters of the jungle and she stopped, dropping to the ground to sit cross-legged. She was not far from where the hologram had been set up, and hoped the invisible Cougar made the connection.

A chill wind was cutting across the field, and she shivered a little. Here, closer to the looming jungle, the afternoon sun was blocked, and the buildings

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didn't shield her. She seemed to sense invisible eyes on her from both directions and felt incredibly conspicuous, sitting in the open like she was.

Over an hour passed, with Star giving her periodic status reports on the Cougars. The two followers were keeping well back, and were definitely not happy. But the leader was watching. From time to time he would pick up the doe, and then put it down.

Somehow that made her feel a lot better. *He was as nervous about this as she was.*

Then she heard a rustling in the underbrush and Star's simultaneous warning.

Once again, he picked up the field-runner. He had to do this, or he would not be considered a fit Speaker. Trying and being hurt or killed was fine, he would gain status and respect. But to be frightened out of trying; that would destroy him.

He threw the limp body over his shoulder, staggering under the heavy load. He eyed Long-Tail with respect. It had not taken her long to run down and kill the runner and she had brought it back easily. He wondered if she was mated with Marrow-Sucker. He felt sure he could beat the male warrior in a challenge. But not now. He turned away and looked out at the black-furred sky-creature that was obviously waiting.

He pushed through the remaining bushes at the edge of the field and stepped out on it, cringing at the alien feel of the short plants that grew on it.

He saw the stubby sky-creature look up as he came out of the jungle, the strange sound he had heard before coming from the little square pouch that hung by its waist. The creature's mouth opened and he heard the same types of sound come from it. *Speech?* he wondered. Then as he stopped, the creature suddenly rolled over onto its side, baring its belly and throat in submission.

Tension fled his neck and arms, it *was* communicating. It wanted to make contact, too, But the smell! Suddenly he felt exposed and vulnerable and he dropped the runner on the ground, crouching and twisting his own neck to bare his throat, too. Then he fled back to the forest and collected the all-too-willing guards to make the journey back to the gathering-place.

Julie stared at the tall figure emerging from the woods. The hooves of the elongated doe he carried brushed the ground both in front and behind him, but she realized that he still stood almost as tall as her. His steps were hesitant and his muzzle was twitching nervously, flashing hints of his incisors. He stopped when about twenty feet away. Star's voice came from her belt. "I would—"

"I kno-ow," she cut him off softly. "Shut u-up and don't confuse him." She let herself fall to her side and rolled to expose her stomach and tilted her head back, looking away from him even as she prayed softly. After a moment, she looked back at her visitor, without changing position. He stared back at her, pupils wide in the yellow eyes as he stood in the shadow. For several minutes they kept looking at each other, and then he abruptly let the doe slip to the ground into a graceless heap as he spun and melted back into the dense woods.

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She lay and stared after him for a long while. Star's voice broke her concentration finally.

"He's gone."

"I know. I'm just savoring the moment." She felt an incredible surge of excitement overwhelming her. "We've made contact! Actual bloody contact! Woeow!" She let out a yell and got to her knees and jumped exuberantly up in the air. Then she pulled her computer up off her belt. "Get your grey cells, or micro-machines, or whatever you use, together. We've got a lot of work to do!"

She turned the computer off and stood looking at the darkening forest for a long time, her eyes moist, her mind whirling. She couldn't wait till her next meeting with the elusive Cougar leader!

A chill wind cut across the lawn and reluctantly, she turned back to the waiting domes of the city. She saw Ken standing by the door patiently and suddenly felt warm again. She smiled. Then Ken came towards her, a beaming grin on his face as he extended his arms towards her. ■

Editor's Note: This story is a sequel to "StarStep," which appeared in our April 1990 issue.

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the reference library

By Tom Easton

The Hour of Blue, Robert Froese, North Country Press (P.O. Box 440, Belfast, ME 04915), $16.95 hb, $11.95 pb, ? pp.
Brain Rose, Nancy Kress, Morrow, $17.95, 288 pp.
Redshift Rendezvous, John E. Stith, Ace, $3.50, 250 pp.
Only Begotten Daughter, James Morrow, Morrow, $18.95, 256 pp.
The Microverse, Byron Preiss, ed., Bantam, $29.95, 352 pp.
The Old Funny Stuff, George Alec Effinger, Pulphouse Publishing (Box 1227, Eugene, OR 97440), $25.00 hb, $4.95 trade paper, $50.00 deluxe leather, 116 pp.
Solip:System, Walter Jon Williams, Pulphouse Publishing (Box 1227, Eugene, OR 97440), $35.00 hb, $10.00 trade paper $65.00 deluxe leather, 71 pp.
Journal Wired, Andy Watson and Mark V. Ziesing, eds., Mark V. Ziesing (P.O. Box 76, Shingletown, CA 96088), $7.95, 126 pp.

Every once in a while, I come across something nice. Sometimes that something comes from a small press. I learn about it either because the publisher hits me with a review copy or because the author is someone I know—often a member of the SF community—and *he* (or she) hits me with a copy. The latter is what happened with Barry B. Longyear's *Saint Mary Blue*. I promptly began to rave about it, a number of you wrote to say I couldn't have been righter, and I understand sales have been very, very good for a small press offering.

Now, here's **The Hour of Blue.**[1] I don't know the author, but the publisher, William M. Johnson, recently set up shop in my town. We became acquainted, he started telling me about the manuscript, and I said, "Let me see it. Maybe I can review it."

Indeed I can, for I haven't been so impressed by a first novel since . . . I

[1]Is there something about the color?

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have to scratch to recall anything that has ever come close. It is thus a shame that the author had to undergo the frustration he did in finding a publisher. As Bill Johnson tells me the story, Robert Froese is an assistant professor of English at the branch of the University of Maine in Machias. He once worked as a technical writer, he has committed a few short stories in a literary vein, and he has written on Bester and Vonnegut. But when he shopped his manuscript around the New York publishing houses, he got told, "Nice stuff, but try a regional press." In due time, he wound up with North Country Press, and that outfit is going to make a lot of money from the book. So will Froese, for *The Hour of Blue* is award-winning material—look for it the next time they announce Nebulas and Best First Novels and Hugos and so on—and it has the potential for an exceedingly powerful and charming movie, something like a combination of *On Golden Pond* and *No Blade of Grass*.

So why wouldn't the big commercial publishers touch it? Very simply, it isn't commercial in the current sense. It has no violence to speak of. It has very little sex. It is relatively contemplative. It is strong on setting and character. And it is set in Maine, far from the urban centers of our civilization.

Yet it is a wowser. The opening scene gives us an individual of uncertain history who is on the run from the US authorities. He is encamped in a South American rain forest, and that rain forest is somehow regenerating faster than humanity can destroy it. The second scene steps back in time: the story's protagonist, Amos, is a computer expert hired by Maine's Forest Service to put satellite information on computer as a real-time automatic forest inventory. One day, the satellite data looks funny. Proper processing soon reveals that concentric rings of some unknown disturbance are spreading through the forest from a central point on the shore of Penobscook Bay (named as a hybrid of Maine's Penobscot and Cobscook Bays), not far from where bulldozers are tearing up the ground to build a nuclear power plant.

Amos leaves the state capital to investigate and finds . . . What? "Special children" who can talk to birds and deliver strange messages from a higher power. A woman who, in her studies of dolphin communication, found a directional component in alarm cries and followed that aural compass to Penobscook Bay. A plague of catatonia. A trio of medical researchers who understand the plague, the alarm cries, the bull's-eye disturbance all as interconnected, all as a sign that Earth itself, the Gaia of that famous Hypothesis,[2] is awakening, is resenting humanity's environmental depredations, and is about to do something drastic. The evidence builds. The mood grows spookier and spookier. And the ending justifies the opening scene, even though there is no real resolution of the story's basic conflict, but rather a mystery made clearer and a vast change in the nature of reality predicted.

Are there any defects? Of course, for there is no such thing as a perfect first novel (or, indeed, a perfect novel). For one thing, that ending does strike me as a little hasty. The movement from Maine to South America does need a little more justification, and future changes, Gaia's response, could be ren-

[2]James Lovelock's Gaia Hypothesis says, in essence, that the planet acts *as if* it were intelligently, deliberately determined to maintain its suitability as an abode of life. The truth is one of innumerable interlocking feedback mechanisms, but the same truth describes a human being as well. It is very tempting to take Lovelock that one tiny step further.

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dered more precisely. You may not agree, but even if you do, the story remains of such stellar quality that it soothes the aggravations of my soul and consoles my cynicisms about both modern publishing and the future of the world.

You, too, will be glad you read it.

Gaia must be in the air. Nancy Kress spells it "Gaea," but it's the same Earth Mother at the heart of her latest novel, **Brain Rose.** Sadly, the book is flawed because Kress devoted too little of her energies to checking her bafflegab—for instance, the AIDS virus is *not* a "slow virus"; such viruses take twenty or thirty years to cause illness—and straighten the kinks in her logic.

Her century is the twenty-first. AIDS has been licked, but only after it rivalled the Black Death by reducing the world population 20 percent in the 1990s and left a legislative legacy of rabid homophobia. "Gaeists," sponsored by industry, are strenuously pushing the idea that whatever humans do to the environment is A-OK; after all, humans are natural (they are, of course), and their actions are both natural (they are) and benign, for Gaea can always be counted on to compensate. They fail to realize, as Robert Froese does, that Gaea's compensations need not be themselves benign, at least from the human point of view.

Now there is another plague, one that destroys the ability to form memories and reduces its victims to living the same day over and over and over. At the same time, there is a technology of "previous life access surgery" which, by removing wired-in inhibitors of access to the human species' racial memory or overmind, in which the memories of all humans who have ever lived are holographically stored, makes it possible for people to experience memories from the lives of long dead predecessors. As described, the surgery should make all past human lives available to the "plazzed" individual, but Kress insists that one can remember only certain lives, those of people whom one has in some sense been, as if reincarnation were real.

The tale opens as Robbie Brekke, Caroline Bohentin, and Joe McLaren, among others, converge on the Previous Life Access Surgery franchise in Rochester, New York. Their pasts and presents are revealed bit by bit, their characters become as real as anyone could ask. Their new memories reveal that these people were in past lives interconnected; for instance, Caroline was once Robbie's mother. Even stranger, of all the kinship ties recorded for all the thousands of plazzed, almost all center on Robbie Brekke. Stranger yet, analyses of incidence and transmission statistics for the memory plague reveal that Robbie is somehow a focal point for that as well. Strangest of all, and most marvelous, says Kress, *anyone who has had or will have in the future the previous life access surgery is immune to the memory plague.*

Why the italics? Well, I can accept that the access surgery might somehow block the effects of the slow virus that causes the plague. But the plague, once one develops it, destroys the mind and the ability to ever again do anything new. *Of course people who get the plague don't get plazzed!*[3]

Such things destroy every shred of an author's credibility. It does not matter that her characterization is marvelous,

[3]Yet plazzing is a cure for Alzheimer's and multiple sclerosis. Might not the parents and spouses of plague victims have them plazzed, in hope of a similar cure? Kress dodges the question.

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that her plotting is grand, that her conclusion—a Gaea striving toward consciousness, toward being able to enlist humans on her behalf, toward in fact an ultimate compensation for human depredations—is of stirring scope. She blew it by insulting every reader who knows how to think.

I was a little skeptical when I picked up John E. Stith's **Redshift Rendezvous.** The package promised an interstellar ship that carries freight and passengers through a hyperspace where the speed of light is just a few meters per second, yet people are somehow immune to the light-speed limit —that is, aboard the *Redshift* relativistic effects are part of daily human experience.[4] Details depend on gravity, which varies according to which of the ship's decks you are on. And the ship itself, because of the way normal space maps into hyperspace, is larger than our Solar System.

The skepticism was because it all seemed a bit much to swallow. It persisted through the first portion of the book, while Stith set his scene, laid down his ground rules of warped physics, and posed the story's problem: murder most foul! Someone is killing the *Redshift*'s passengers!

The protagonist is Jason, the cold, loveless, and very competent product of an abominable childhood. He is hunting for a missing crew member when matters come to a head: pirates emerge from hiding places to take over the ship and aim it toward a world that claims to be a religious retreat for benefactors of humanity. The rest of the tale is Stith's working out of how Jason must use the warped physics of hyperspace to conquer the pirates. In the process, Jason finds love, the religious retreat proves to conceal one of the nastiest nests of vipers you will ever hope to avoid, and the story itself becomes far more absorbing than I had first expected.

So. If you love writers who play techy games with reality, or if you can tolerate such games for the sake of the story, pick this one up. You'll find games galore, but also a nicely developed plot and a few fairly well-rounded characters. Over all, a nice package.

I've said before that the closer we get to the turn of the millennium, the more Second Coming stories we'll see. There isn't really anything remarkably profound about the prediction, SF writers being the myth-lovers they are and people in general being pretty superstitious folks. Nor has there ever been much of a shortage of such tales. But there do seem to be more and more stories that fit the millennial pigeonhole.

Happily, some of those stories fit the pigeonhole only on the surface. James Morrow's latest, **Only Begotten Daughter,** is one such. It begins when Murray Katz, a Jewish recluse living in an Atlantic City lighthouse, learns that his latest donation to a local sperm bank has spontaneously generated an embryo. The embryo is ensconced in an artificial womb, and when Murray sees it, he is immediately moved to swipe the machine, embryo and all. Fortunately, shortly after he leaves the premises, militant Revelationists bomb the sperm bank. His theft is never detected. And so is born Julie Katz.

As one might expect of an immaculately conceived daughter of God, Julie is a precocious child. She walks and

[4]Stith is aware of the difficulties in what he is doing. In the essay that concludes the book, he says he feels obliged to leave certain inconsistencies in the physics of the *Redshift*'s reality alone for the sake of the story.

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talks early. She walks on water. She makes the blind to see. But Daddy is a wise fellow. He cautions her that unless she hides her light, the same fate that struck down her half-brother will surely get her, too.

Yet Satan just loves religion. And Christians have become all too meekly loving in recent years. He wants a new church, a Church of Julie Katz, that will get people all worked up again, preferably just as they were in the days of the crusades and the Inquisition. To generate it, he goads poor Julie into doing miracles. She tries to resist, espousing a faith in Heisenbergian quantum uncertainty and in a God, her Mother, who exists only outside the realm of the knowable, of physics and biology and space and time. She writes a tabloid advice column. She falls in love and refuses to heal even the alcoholism of her best friend. But then the Revelationists attack Atlantic City with fire and sword, aiming to destroy Babylon and thus bring on the Second Coming. Julie puts out the fires and, when the adulation of the mob proves too threatening, flees with Satan to Hellish refuge. While there, she learns that Hell is the destination for everyone whose tribe, church, club, or what-have you has ever been wished there.

That is, Heaven is a *real* restricted neighborhood, having only three residents. Even Jesus Christ is in Hell, where he comforts the damned with a water he has turned to a powerful painkiller. Julie joins him in his ministry, though that doesn't save her from growing bored. Fifteen years later, she returns to Earth minus her godhead, miracle-less, to find New Jersey seceded from the Union, a theocratic republic under the heretic-burning thumb of the Revelationists. She flees to America and marries. Having learned something from Jesus—the mission of the Children of God is to comfort the suffering—she finds good deeds that need doing among the homeless. And then, goaded by Satan, the Revelationists kidnap her. Their aim is . . .

Like many who see the world clearly, Morrow is driven frantic by the insanities committed in the names of the gods. He has written a work of satiric imagination as compassionate and horrifying as the book's publisher bills it. If the publisher also calls it "funny as hell" . . . Well, it has its moments, yes. But *Only Begotten Daughter* is *not* funny. It has fangs, and it bites. It is also very warm, very human, very humane. Turn it around and, like many of the strongest satires, it is a recipe for utopia.

Does it bother you that though the time for much of the story is the early 21st century, technology is little advanced over that of today? The differences lie almost entirely in the millennial fever of the Revelationists (signs of which are abundant enough today to frighten anyone). The result is a tale with a curiously anachronistic feel. Or does it bother you that the ending has elements, such as a Satan defeated without a foreshadowing clue, that might better have been edited out?

Never mind. The flaws are minor. The whole is a vastly impressive work of the satiric art, and I highly recommend it.

Byron Preiss has done it for *The Planets* and *The Universe*. Now here's **The Microverse,** one more of his well-illustrated, patented interleavings of fact and fiction, of essays by leading scientists alternated with short stories by leading SF writers, each essay-story pair being on the same topic. It moves from the merely microscopic through living

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cells and genetic codes to molecules and subatomic particles to the connection between tiniest and largest, between the dimensionless singularity of the Big Bang and the cosmos itself. The essayists are Edward W. Kolb, Sheldon Lee Glashow, Alvaro De Rujula, Leon M. Lederman, Gerald Feinberg, Philip Morrison, William M. Gebhart, William A. Haseltine, Marcel Bessis, Linn W. Hobbs, and Jean Paul Revel. Their work is sometimes determinedly jolly in their efforts to strike the popular vein, and it generally requires the sort of familiarity with modern physics that a faithful reader of *Scientific American* would have. That is, this book won't do as an introduction to science for the family's eight-year-old. With that caveat, it does give a very nice overview.

What about the stories? Most, while always inoffensive and occasionally ingenious, betray their origins as work assigned to fit a theme. Paul Preuss's "Half-Life," in which Madame Curie, on her death-bed, finds time turning fluid, and Gregory Benford's "Mozart on Morphine," which tracks a mathematician's progress toward his Nobel Prize, are easily the best. The other contributors include Michael Bishop, Isaac Asimov, Harry Harrison, Poul Anderson, Robert Silverberg, Robert L. Forward, Connie Willis, David Brin, and Rudy Rucker.

Pulphouse Publishing continues to do interesting things. One of the latest items from that small Oregon press to land on my desk is the first issue of a series called *Author's Choice Monthly*. It's **The Old Funny Stuff,** by George Alec Effinger. It consists of one poem and five short stories, one of them written just for this volume. All the stories are strange, witty, amusing, sardonic, as in "White Hats," in which a horde of pulp heroes comes to the aid of a mugged couple, or "The Aliens Who Knew, I Mean, *Everything*," in which the nuhp solve the population problem by making everybody run away. The new tale, "CHESS.BAT: A New Wave Story," may be the strangest of them all, largely because Effinger focuses on form—the New Wave emphasis, indeed—at the expense of content. If you don't care for Effinger, the *Author's Choice Monthly* series is mapped out well ahead. In months to come, it will feature Lisa Goldstein, Lewis Shiner, Jack Williamson, Edward Bryant, James Morrow, James Patrick Kelly, Ron Goulart, Spider Robinson, and Michael Bishop, among others. Still further in the future, if the series is well received, we will see Esther M. Friesner, Mike Resnick, Kim Stanley Robinson, Susan Shwartz, Kate Wilhelm, Charles de Lint, Harlan Ellison, Joel Rosenberg, and more.

The second Pulphouse item I wish to mention is **Solip:System,** a novella by Walter Jon Williams. Taking place shortly after Williams's novel *Hardwired* ends, it is the tale of Reno, whose body has been killed but whose mind is recorded in a computer. That mind is used to take over the mad villain Albrecht Roon; indeed, by the time the story is over, Reno has taken over many of the characters (hence the title). Yet the story is a bit more than clever extrapolation of what might happen given the capability to treat a brain like a floppy disk, for the Reno recording is not perfect. It has blank spots, and in those blanks Roon continues to live. From this Williams draws the sort of pain that can give a character depth and stimulate the reader's empathy. His success is limited partly by the space he allowed himself, but perhaps more by the grotesqueness of the situation.

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* * *

Journal Wired is a curious and admirable item from Andy Watson and Mark V. Ziesing. It is a quarterly magazine, with no ads or subscriptions, in the guise of a paperback book or, in the words of the ad copy, "a recurring mixed anthology with too long a shelf life not to be a book." In other words, it's a magazine disguised as a book so the store owners won't yank it off the shelf after only a month. And if that sounds like an identity crisis, well, *Pulphouse* has shown it can work.

In the introduction, Watson says that he and Ziesing are aiming "for a worldly perspective, one resistant to personality cult mythology, public relations hype, and marketing rhetoric. . . . Another of our goals . . . is to publish fiction that defies categorization, blurring the distinction between popular genres and the so-called 'mainstream.' . . . solid stories, well written and well told, demonstrating exceptional command of language and concept. Thought-provoking, yes, and entertaining . . .truly *modern* in the sense of incorporating meaningful contemplation on issues relating to . . . all that makes the current era so radically different . . ."

In the letter that accompanied the proofs of the first issues, Watson added that "Although the emphasis of *Journal Wired* is not specifically science fiction, the contributors (and, we expect, most of the readers) are from the sf community." This means an interview with Iain M. Banks, short stories by A.A. Attanasio ("Atlantis Rose" revisits the old idea of ionospheric brainsuckers) and Rudy Rucker ("Drugs and Live Sex—New York City, 1980" is not SF at all), and articles by John Shirley (on screenwriting for Hollywood) and Lucius Shepard ("Waiting for the Barbarians," a vigorous go-to-hell for SF crud). Add in another interview with the late Abbie Hoffman and "commentaries" on business domination of the arts by Andy Watson and on the alienation of theater from its Cro-Magnon roots by J.B. Reynolds, and you have quite a satisfying collection.

It's not very large, but Watson and Ziesing say they hope to make it grow as reader response justifies—and enables—the investment. So go ahead —encourage them. The price isn't too steep, and your reward, now and in the future, will be more than adequate.

ANADEMS

A quick toot of my own horn: My novel *Sparrowhawk*, which you saw as a serial here last fall, will be appearing later this year, in a somewhat longer version, from Ace.

A toot for Dr. Robert L. Forward: He wrote recently to tell me something interesting about the publication history of his 1982 *Analog* serial *Rocheworld*. The original manuscript, he says, was about 150,000 words. He condensed it to 60,000 for serialization. A 100,000-word version appeared as *The Flight of the Dragonfly* from Timescape, just about the time that label vanished. Baen Books brought out a slightly longer version. And now Baen is bringing out a 155,000-word version with all "the best features of all the prior versions," says the author. It will be available in April 1990.

Sound confusing? Think of how confusing and frustrating and aggravating it must have been for Dr. Forward! And then wish him luck with *Martian Rainbow*, of which he says, "I terraform Mars in six days (so I can rest on the seventh)." It's just been accepted by Ballantine/Del Rey, and you should be seeing it soon.

And a toot for a stranger: An inter-

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esting item arrived in the mail the other day, apparently in response to my review of Ben Bova's *Cyberbooks*. It was an MS-DOS shareware (try it, then pay) program called "IRIS: The Virtual Book Processor," by Ted Husted (UserWare, 4 Falcon Lane East, Fairport, NY 14550-3312), which allows one to navigate pretty much at will through an on-disk book. I ran it through its paces, and I'm impressed.

IRIS includes capabilities that look a lot like hypertext, and a separate version (called PRISM) is available for writers of books to be read with the program. Husted says he plans to distribute such books as fast as authors will write or convert them. So far, his list includes "The Hitchhiker's Guide to Science Fiction" ("a compendium of the many worlds and wonders found in award-winning science fiction") and "The Virtual Society" (on the modern library and its future) by Harvey Wheeler, director of the Virtual Academy, a modem-based education resource for elementary and high-school students. A book-disk goes for $4 plus $2 shipping and handling; IRIS costs $8; PRISM is $16; registered (paid) users of IRIS or PRISM get a catalog of available books.

I won't claim that Husted represents the wave of the future, but his efforts do seem worthy of encouragement. If you're interested, in the technique or the products, write him. ■

IN TIMES TO COME

●Science fiction detective stories are relatively rare because of the special difficulties of combining the two forms. Maybe the secret is to add a third ingredient, as John E. Stith does in next month's lead novella "Naught for Hire." Private eye stories lend themselves *so* well to satire, and there's *so* much to satirize in the trends Stith extrapolates.... Both crime and the quest to solve it are inextricably rooted and mired in a not too distant (and *maybe* not even too far-fetched!) future in which affable artificial intelligences have become a pervasive feature of everyday civilized life. What's wrong with that? Well, artificial intelligences are created and programmed by *human* intelligences.... Artist William R. Warren, Jr., had a lot of fun with it, and I think you will, too.

We'll also have stories by Christopher Anvil, George W. Harper, Kevin O'Donnell, Jr., and Charles Sheffield. Stephen L. Gillett, Ph.D., has a fact article with the tantalizing title "Fire, Brimstone—and Maybe Life?" It's often pretty much taken for granted that life must be based on carbon, but there *may* be a few other possibilities. Sulfur? Dr. Gillett has just the place for it!

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brass tacks

Stan:

Your "greenhouse" remarks are pefectly true, but somehow miss the point just a bit. Granted, you do throw in the advice early on that . . . "We'd both better pay attention and try to find out. . . ."

I shall not insult you by assuming that you really meant to place top priority on selecting the proper label for the phenomenon. Even if you meant, as I'm sure you did, that we should try to determine whether our recent meteorologic anomalies are casually connected with an overall global warming. . . . I can only partially concur. It's important, sure, but there is something much more so.

We need not "prove" that the recent peculiar behavior of the jet stream is anthropogenic before we start making contingency plans. It is plausible enough, and the consequences are dire enough, that someone, somewhere, should be studying the "worst case" scenario.

Trouble is, that scenario is so bad that no one even wants to think about it. Changes in the jet stream "sinusity" may endanger more lives than a rising ocean. This year it's the Kansas wheat and the Ohio corn that our crazy climate has cut into. Not to worry, we can survive . . . but what about next year, and the one after that? An unstable climate plays hob with agriculture—and our planet's resources are stretched already.

The real problem, and the one nobody wants to recognize, is that there are too damn many humans on our planet, all of them striving to improve their lot. Which takes energy. Which means more fossil fuels. Which means another increase in the *rate* at which we are screwing up the planet.

WARREN RAYLE
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To the Editor:

I have read your editorial in the September issue with interest and am moved to respond to it.

Your thesis that there is much smoke and fire from those who quickly pick up the cudgel of a cause without waiting to see if it warrants the definition and direction of a "Cause," fits one of my favorite prejudices. However, I would not exclude any category of humans from the above description. It seems to me we all have the two buttons of rationality and irrationality, and are not always aware when we push one or the other, or when someone else does the pushing. I continue to be affected and affronted by the belief that the terms "science" and "scientific" attached to human endeavors give some protection from deceit and/or irrationality that may or may not be intentional. Reading Steven J.Gould, "The Mismeasurement of Man," and Robert O. Becker, "The Body Electric," wherein they chronicle how the prejudices of scientists have influenced past and present-day knowledge, does not give confidence in hearing a "scientist" explain a present-day reality as *truth*.

It also seems presumptuous, although a common response, to speak of a human-caused or human-related catastrophe in terms of "the world is doomed!" I have a notion the world will get along just fine after we human-type creatures manage to kill ourselves off. Our time frame makes it difficult to realize the world is quite ancient compared to the age of mankind, and the changes that have occurred during those eons are consistent with every imaginable condition. It's quite likely our demise won't be noticed.

HANK DEVOSS

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Dear Dr. Schmidt,

I've been enjoying recent *Analog*s, both fiction and nonfiction. It was especially pleasing to read Doug Beason's "The Long Way Home," (Oct.) just before going to Albuquerque's Bubonicon where I found myself on several panels with him. I also regularly find myself wanting to respond to your editorials. Perhaps I might comment here on your, "The Blind Men, The Planet, And The Wolf," in the Sept. *Analog*.

You refer, on p.10, to our tendency, "to dismiss concerns about things like the greenhouse effect by pointing out that there have been many prophesies of doom in the past, none of which have come to pass." As you say, this "is *not*, by any stretch of the imagination, a rigorously logical proof that there are no problems big enough to warrant serious concern."

Many prophets of doom have been correct, including the original of the genre, the biblical Jeremiah, who accurately prophesied not the end of the world, but the destruction of his home country by a foreign conqueror. This entire subject of an ominous future tends to elicit extreme responses. I believe there is an identifiable psychological mechanism at work that helps explain why people react as they do.

While working as a Jungian analyst, I often noted dreams of death and destruction, either personal or general. Most people's reaction to these images were either to panic or to disregard them. Needless to say, the dreams almost never literally came true. However, these images of doom did tend to occur in association with a major change in circumstances and/or outlook.

It appears to me that the human psyche identifies with whatever is familiar so thoroughly that the end of a familiar way of life acquires the connotation of

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death. It is all too easy to react to this sort of imagery in extreme and dysfunctional ways. As in Jeremiah's day, however, our familiar way of life may not necessarily be the same as the end of the world.

Jeremiah's people still exist. The fall of Rome led to the emergence of Christian moral values, which have at least slightly countered our civilization's continuing barbarity. The collapse of medieval civilization led to the rise of science, commerce, exploration and the wonders of modern technology. Each such social, political, and often ecological crash has entailed a lot of suffering and destruction. Each one has also both involved cultural continuity and major change in attitude. Might not our current crisis lead to something similar? I believe one of the things that has brought so much respect to such writers as Robert A. Heinlein and Ursula K. LeGuin is their various visions of a future which incorporates both crash and progress, both cultural continuity and genuinely different attitudes. In many ways, that is what Science Fiction is all about.

As your editorial suggests, extravagant prophesies of doom should not distract us from real but slightly less extreme problems. I believe we can approach these problems a little more effectively if we recognize our own psychological reaction to them. Our world may not be doomed. Our familiar way of life probably is. If we can stand the prospect of real and major change, we have a lot better chance of meeting that change in a conscious and constructive manner.

UNCLE RIVER/STEPHEN KAUFMAN, PH.D.
(PSYCHOLOGY OF THE UNCONSCIOUS)

Dear Dr. Schmidt,

I am writing in regard to a recent book review column by Tom Easton, where he reviewed the book *Cluster Command*, by W.C. Dietz and David Drake. You see, I am a father, a suburban homeowner, a government employee, a reserve officer, and I even teach a Sunday School class in my local church. I'm not a member of the NRA, in fact I don't even own a gun. I generally vote for Democrats. I am, however, also a fan of military and adventure science fiction. Since I like these books, I guess that makes me one of the readers Tom is referring to when he says, "we all benefit if those readers who love them are kept off the streets."

The above leads me to the point of my letter. Why would someone like me, or any rational person, enjoy reading tales of mayhem and destruction? Tom seems to believe that it is some sort of sick fascination with death, blood, and power. I guess with all the success of slasher horror films lately, this must be true of many people. Yet I find that my favorite stories don't involve dealing destruction so much as avoiding it. One of the things that really grips me while reading is the fact that the protagonist or hero is in danger. Sometimes that danger comes from nature. Sometimes it comes in the exploration of the unknown. In a good romance story the protagonist's heart is in peril. In psychological thrillers their mind is in peril. In horror stories the threat is often a fearsome monster. And sometimes danger comes from others in the form of either the personal violence we find in a spy or mystery novel, or the institutionalized violence we find on the battlefield. It is the vicarious thrill of facing and overcoming danger which most often attracts me to the book. It is emphatically not what I seek in my real life, though. My own brushes with danger have convinced me that adventure

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is best enjoyed in your own armchair, safe and snug in your living room. Also, my favorite stories are not the ones where the hero survives by being that much meaner and more vicious than the villains. Instead, like in the stories John Campbell used to print, I like the hero to think his way out of his problem, or prevail by being clever.

I must also protest Tom's statement that " . . . Galactic Empires were shown long, long ago to be politically and socially ridiculous." I must agree that an empire on an interstellar scale would not be stable, nor long lived. If you accept the improbable convention of faster-than-light travel, though, you must admit that governments which include multiple star systems are at least possible. And as authors like Arnold Toynbee, and more recently Paul Kennedy, have shown us, the fact that no one has ever achieved long-term hegemony over mankind does not mean that no one will try. I would like to believe that enlightened democracies will be the only governments to rule mankind in the future, but dictators have a way of springing up like weeds throughout history.

Now, as far as "nictitating nostrils" are concerned. Yes, it is not the most correct usage of the word I have ever seen. But you must admit the alliteration is catchy. If the phrase had come to my mind, I would have been compelled to throw the Oxford English Dictionary to the wind and use it myself. But then again I enjoy stories about square-jawed, steely-eyed heroes, a description which Tom probably reacts to like he does to fingernails on a blackboard. One man's pleasure is another's poison. But I find literary details like that to be rather insignificant. If there is one thing about the science fiction community which irks me, it is the penchant for nit-picking over small details. I must confess I find Tom's fascination with a single phrase in an entire book to be a form of literary onanism itself.

I won't say that books like *Cluster Command* are high literature. But they are entertaining to many people, not all of them "adolescent bang-bang freaks." As David Drake pointed out in the panel which Tom discussed, one of the major reasons he writes military fiction is to remind people what the horrors of war really are. The man does not come across as a crass exploiter of man's baser instincts. And a review of modern science fiction shows that many of the stories available, especially cyberpunk stories, are at least as violent as military SF stories. As an example of violence in stories outside of the 'military' circles, I could point to Tom's own "Sparrowhawk" which opens with a quite graphic portrayal of a futuristic terrorist attack. So I think that some of the bad press, which implies that military SF stories have a corner on literary violence, is undeserved.

In closing, I must say that each month Tom's reviews are one of the first things I read in the magazine. I don't always agree with him, but that doesn't mean I don't enjoy his column. I look forward to his continued candor in the future.

ALAN BROWN

Dear Stan:

It's distressing to see *Analog* reviewer Tom Easton resort to a tactic outside commentators have all too often used against SF—judging books by their covers. I refer to his most recent attack on David Drake which amounts to claiming that since military hardware appears on his covers, Drake's books glorify war.

Not only does this argument fail logically, but Easton neglects to specify

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which books and covers are at issue. But let's assume Easton refers to the Hammer's Slammers series though this is scarcely the whole of Dave's output. Exactly how does Paul Alexander's slightly abstract illustrations qualify as "pornography of violence" or "mere Conanism"?

These unsubstantiated assertions serve to distract attention from Easton's failure to demonstrate the alleged glorification of war in Dave's fiction. Like sundry book-burners, Easton doesn't grasp that representation isn't the same as approval. Quoting the author's own aversion for the horrors of war doesn't soften the criticism. On the contrary, it implies that the critic understands the work—and perhaps the nature of war—better than the war-veteran author.

Since Dave and I coedited two SF anthologies in honor of Rudyard Kipling, I see certain parallels between Easton's hostility and the reactions of tender-minded critics to Kipling's rough fighting men. In both cases, the writer's "crime" is to depict soldiers neither as monsters nor heroes but men "remarkably like you." If Easton doesn't like this message, let him devote his pages to other things—there are a thousand new SF books a year awaiting review.

In closing I might mention that my first novel and other works were praised by Tom Easton. But I certainly don't wish to have anything of mine reviewed by him in the future and will so instruct my publishers.

SANDRA MIESEL

Mr. Easton replies. . . .

Dear Stan:

I think it's very easy to read Drake as glorifying violence. Certainly, he seems to be marketed to the shoot-'em-up-bang-bang-freaks. So I'll stand by my guns. But I do wish I knew why the devil Ms. Miesel thinks I was judging Drake's work by the cover on the books.

TOM EASTON

Dear Dr. Schmidt,

I am writing to correct errors in Alexis A. Gilliland's "The Man Who Funded the Moon." This story simply wasn't researched properly.

First, two glaring referential errors: the "Tactical Bombing Command" referred to does not exist, while the "Air Transport Command" was inactivated in 1948. It was replaced by the Military Air Transport Service, which was redesignated the Military Airlift Command in 1966. MAC is now a component, along with Military Sealift Command and the Army's Military Traffic Management, of the US Transportation Command. Planning is performed by USTRANSCOM, while operations are conducted by the units at specified command and lower echelons. Several such unified command structures now exist specifically to address the problems of inter-service cooperation.

As for the idea of divvying up the Air Force, and shutting down all those "useless" bases, where does the author propose all the Army's new missiles, and Navy's new transport aircraft operate from? The "useless" bases would simply be redesignated. This would cost, rather than save money. Even if the facilities did exist in other branches, thousands of assorted jet mechs, AGE technicians, loadmasters, engineers and security police would have to be recruited and trained or transferred from the Air Force. I can see no economic advantage to this scheme.

Tactical Air Command's transfer would cause even more problems. TAC provides escort, intercept, and ground support missions, among others. Most of these missions are performed by

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multi-role aircraft, thus reducing cost. The author's proposal would necessitate either buying twice as many dedicated role aircraft, or transferring TAC to the Army as is. Both would be expensive and confusing to a TO that works. I see nothing to be gained here, either.

On the subject of manned bombers, again the author is years out of date. Although gravity bombs still exist for strategic purposes, most missions today are based on the Short Range Attack Missile and the Air Launched Cruise Missile. Utilizing SRAM/ALCM enables a bomber to become a man-in-the-loop intermediate range weapon. With a 2,400 kilometer stand-off, the aircraft becomes much harder to hit. It has post-launch flexibility, and the ability to be programmed or recalled. Bombers are still a viable first-strike weapon.

Conventionally, the worth of the strategic heavy bomber was proven during the LINEBACKER I & II missions in Vietnam. A 250 kilogram bomb blasts a crater 15-20 meters in diameter and 3-5 meters deep. It has a lethal radius of up to 300 meters. The B-52H has a capacity of nearly 30,000 kilograms. During the LINEBACKER missions, better than 50,000 *tonnes* were being dropped monthly. I'm afraid I can't consider the ability to drop almost two kilotonnes a day conventionally to be an ineffective weapon.

Today's military sees the Air Force providing tactical air control to the Army's Airborne and Ranger units; pararescue men, combat controllers and weather forecasters to the Special Forces; strategic reconnaissance and heavy bomber support to the Navy; transport to all branches and many goodwill civilian causes; and training to literally thousands of soldiers, sailors, marines and troops of friendly foreign nations each year. The other branches return the favor, providing flexible, efficient "total force."

The military does have its problems, and welcomes constructive criticism of them. However, such criticism should be educated and researched. *Analog* usually provides stories of such caliber, and I look forward to seeing such again in the future.

MICHAEL Z. WILLIAMSON
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Chaunute AFB, IL 61868

The author replies. . . .

Dear Stan,

Michael Z. Williamson asserts that the worth of our heavy bombers was proven in Vietnam. It was, indeed, but not as he imagines. Rather than cutting the Ho Chi Minh trail by the occupation of southern North Vietnam, we decided to interdict the trail by strategic bombing. Williamson's figures are impressive and doubtless impressed our strategists, but the outcome of that massive bombing effort was that the Ho Chi Minh trail remained operational throughout the war. A war which, in the end, we lost. Williamson may not consider the ability to drop 2,000 tons of conventional bombs a day to be an ineffective weapon, but it was. We used the B-52H because that was what we had and it didn't do the job for us.

His further assertion that "bombers are still a viable first strike weapon" has not been true since about the time we began MIRVing the so-called "physics packages" in our various ICBMs. The basic reason for this is that bombers are too slow, taking hours to reach targets which missiles can reach in minutes, so that any "first" strike launched with bombers will do little more than precipitate an exchange of missiles. The idea that bombers can be given a strategic role by fitting them with various sorts of missiles is simply

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mistaken. Here the problem is not that the bombers are too slow, but that they lack stamina. Once launched they have to strike or retreat almost at once. Their deployment thus cannot be used to apply diplomatic pressure, only to signal our own growing sense of panic.

Williamson acknowledges that the military has problems. One of those problems, and one which shaped the plotting of "The Man Who Funded The Moon," is that the military has become dependent on nuclear weapons systems which no one, civilian or military, has the will to use. This failure of will is perfectly rational. The costs of using such weapons far exceeds any political benefit which might be obtained thereby. The cost of building such weapons is also not trivial, but the greater cost is that we seem to have lost the will to use *any* weapons. Think about it; when was the last time the US was serious about using force?

ALEXIS A. GILLILAND

■

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a calendar of analog upcoming events

1-3 June
X-CON 14 (Milwaukee area SF conference) at Hyatt Regency, Milwaukee, Wisc. Author Guest of Honor—Christopher Stasheff, Artist Guest of Honor—Joan Hanke-Woods, Fan/Gaming Guest of Honor—Richard Tucholka, First Fandom Guest of Honor—Wilson "Bob" Tucker. Registration—$20 until 2 May 1990, $25 at the door. Info: X-Con Ltd., Box 7, Milwaukee WI 53201-0007.

7-10 June
DEEPSOUTHCON 28 (Deep South regional SF conference) at Southern Inn, East Ridge, Tenn. Guest of Honor—Bob Shaw, Artist Guest of Honor—Darrell Sweet, Fan Guest of Honor—Bryan Webb. Registration—$25. Info: DeepSouthCon 28, Box 23908, Chattanooga TN 37422. (615) 698-7938.

7-10 June
AD ASTRA 10 (Toronto area SF conference) at Howard Johnson Airport Hotel, Toronto, Ont. Guest of Honour—Terry Pratchett, Artist Guest of Honour—Frank Kelly Freas. Registration—C$22/US$18 until 26 May, C$27/US$23 at the door. Info: Ad Astra 10, Box 2776, Station A, Toronto ON M5W 1X9 CANADA.

15-17 June
New Orleans Science Fiction Fantasy Festival at the Bayou Plaza Hotel, New Orleans, La. Guest of Honor—Roger Zelazny, Artist Guest of Honor—Dell Harris, TM—Edward Bryant, Fan Guests of Honor—Frank and Cece Terry. Registration—$15 until 1 April, $20 until 1 June, $25 at the door. Info: The New Orleans Science Fiction Fantasy Festival, P.O. Box 791089, New Orleans LA 70179-1089.

22-24 June
POLYCON VIII (gaming-oriented convention) at California Polytechnic State University, San Luis Obispo, Cal. Registration—$15 until 13 April, $18 until 18 May, $22 at the door ($12/day). Info: Polycon VIII, % SAGA, Activities Planning Center, Box 168, San Luis Obispo CA 93401. (805) 545-9858.

28 June-1 July
Science Fiction Research Association XXI (SF academic conference) at Hyatt Edgewater Hotel, Long Beach, Calif. Theme: SF in the Future: There and Back Again with SFRA XXI. Registration—$80 until 14 June, $85 thereafter. Registration includes conference trip and banquet. Info: Christine and Peter Lowentrout, SFRA XXI Conference Co-Directors, 1017 Seal Way, Seal Beach CA 90740.

23-27 August
CONFICTION (48th World Science Fiction Convention) at Netherlands Congress Centre, The Hague, Netherlands. Guests of Honor—Joe Haldeman, Wolfgang Jeschke, Harry Harrison; Fan Guest of Honor—Andy Porter. Registration—$65 until 31 December 1989. Supporting—$28 until 31 December 1989. This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Join now and get to nominate and vote for the Hugo Awards and the John W. Campbell Award for Best New Writer. Info: Worldcon 1990, Box 95370, 2509 CJ The Hague, Netherlands. Enclose sufficient International Reply Coupons for airmail response.

30 August-3 September
CONDIEGO/NASFiC (North American SF Convention) at the San Diego Omni Hotel International, San Diego, Calif. Guest of Honor—Samuel R. Delany, Fan Guest of Honor—Ben Yalow. Registration—$65 until 1 January 1990, $75 thereafter, $85 at the door. Supporting membership—$25. Info: ConDiego, Box 15771, San Diego CA 92115.

—Anthony Lewis

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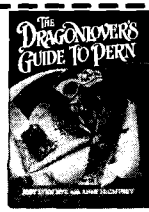

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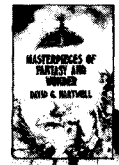

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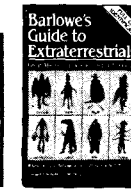

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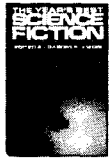

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